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FOREWORD

Symposium on **Advances in Educational Technology** (AET) is a peer-reviewed international conference focusing on research advances and applications of combined use of computer hardware, software, and educational theory and practice to facilitate learning. Today, AET is the premier interdisciplinary forum for learning scientists, academicians, researchers, professionals, policymakers, postgraduate students, and practitioners to present their latest research results, ideas, developments, and applications.

AET topics of interest are:

- Artificial intelligence in education
- Augmented reality in education
- Cloud-based learning environments
- Cloud technologies for mathematics learning
- Cloud technologies for informatics learning
- Computer simulation in science and mathematics learning
- ICT in primary and secondary education
- ICT in higher education
- Learning environments
- Learning technology
- Professional training in the digital space
- Massive open online courses
- Methodology of informatization in education
- Modelling systems in education
- Psychological safety in the digital educational environment
- Soft skills development
- STEM education
- Virtualization of learning

This volume represents the proceedings of the Symposium on Advances in Educational Technology, held in Kyiv, Ukraine, on November 12-13, 2020. It comprises 110 contributed papers that were carefully peer-reviewed and selected from 282 submissions. Each submission was reviewed by at least 3, and on the average 3.1, program committee members. The accepted papers present a state-of-the-art overview of successful cases and provide guidelines for future research.

We are thankful to all the authors who submitted papers and the delegates for their participation and their interest in AET as a platform to share their ideas and innovation. Also, we are also thankful to all the program committee members for providing continuous guidance and efforts taken by peer reviewers contributed to improve the quality of papers provided constructive critical comments, improvements and corrections to the authors are gratefully appreciated for their contribution to the success of the workshop. Moreover, we would like to thank the developers of HotCRP, who made it possible for us to use the resources of this excellent and

comprehensive conference management system, from the call of papers and inviting reviewers, to handling paper submissions, communicating with the authors, and creating the volume of the workshop proceedings.

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PAPERS

FULL PAPERS

Assessing Augmented Reality Possibilities in the Study of School Computer Science

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Keywords: Educational Augmented Reality, Mobile Learning, School Computer Science, STEM Project, Augmented Reality Applications.

Abstract: The article analyzes the phenomenon of augmented reality (AR) in education. AR is a new technology that complements the real world with the help of computer data. Such content is tied to specific locations or activities. Over the last few years, AR applications have become available on mobile devices. AR becomes available in the media (news, entertainment, sports). It is starting to enter other areas of life (such as e-commerce, travel, marketing). But education has the biggest impact on AR. Based on the analysis of scientific publications, the authors explored the possibilities of using augmented reality in education. They identified means of augmented reality for teaching computer science at school. Such programs and services allow students to observe the operation of computer systems when changing their parameters. Students can also modify computer hardware for augmented reality objects and visualize algorithms and data processes. The article describes the content of author training for practicing teachers. At this event, some applications for training in AR technology were considered. The possibilities of working with augmented reality objects in computer science training are singled out. It is shown that the use of augmented reality provides an opportunity to increase the realism of research; provides emotional and cognitive experience. This all contributes to engaging students in systematic learning; creates new opportunities for collaborative learning, develops new representations of real objects. The authors studied the relationship between some factors that influence the introduction of augmented reality in school computer science, such as: the age of teachers, student interest, the use of gadgets in education, play and entertainment style of learning. Several augmented reality STEM projects have been selected. On the basis of expert evaluation, the attitude of teachers to these projects was determined and the most rated of them were evaluated.

1 INTRODUCTION

Today, the topical areas of research for scholars in education are the didactic potential of digital technologies and methods of their application. Modern digital tools create opportunities to complement real space with contextual, dynamic, visual content. Accordingly, such technologies are increasingly being implemented and explored in education.

Augmented reality (AR) is a technology that enriches human sensations with digital data and thus mixes the real and virtual environment. It uses virtual information as an additional useful tool. As a result, a new, more informative and stimulating environment is created.

The principle of the AR program is to use the sensors of the device to read the environment and supplement it with digital, interactive content.

AR applications can be used on different devices such as desktops, laptops, mobile devices. But most AR programs work on smartphones, tablets. Smart glasses, headphones, and other controllers can be further connected to mobile devices. Built-in cameras, GPS sensors, gyroscopes and other sensors are used to recognize objects, images and scenes. After successful recognition, relevant digital content becomes available and is displayed on screen. The purpose of their application is to combine the real environment

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with digital content. This enables the user to receive more information about the environment than is available to him in the real world. The advantage of AR is not only to increase the available information in the environment, but also to create an attractive representation of the world. For this reason, AR is used in many industries such as marketing, design, medicine, entertainment, tourism, education (Iatsyshyn et al., 2019; Hruntova et al., 2018; Rashevska and Soloviev, 2018; Striuk et al., 2018; Zelinska et al., 2018).

The ability to improve the visualization of objects and processes in the learning environment through interactive digital content has generated interest in the using of AR applications for educational purposes. New possibilities of AR technologies for teaching and learning has been analyzed in (Shepiliev et al., 2021). Iatsyshyn et al. (Iatsyshyn et al., 2019, 2020) described examples of AR applications in such industries as the entertainment and gaming industries, tourism, sales and presentations, education.

Classification of directions of using of augmented reality in education and practice of using AR applications are given in the publications (Ranok, 2020; Yuen et al., 2011). The analysis of the papers shows that AR is implemented to different disciplines of elementary and secondary school (Coimbra et al., 2015; Matsokin and Pakhomova, 2020; Matviienko, 2015; Midak et al., 2021) and in the higher education institutions (Barkatov et al., 2020; Klochko et al., 2020; Lavrentieva et al., 2019, 2020). These and many other researchers have found that AR technologies increase the level of success and motivation of pupils and students (Gutierrez and Fernandez, 2014; Kesim and Ozarslan, 2012).

Scientists say that learning in the AR can have a positive impact on the development of spatial imagination, the formation of abstract concepts, the transfer of knowledge, the acquisition of digital skills and experience. Dyulicheva et al. (Dyulicheva et al., 2020), Kolomoiets and Kassim (Kolomoiets and Kassim, 2018), Osadchyi et al. (Osadchyi et al., 2020), Tkachuk et al. (Tkachuk et al., 2017) identified AR as an important prerequisite for implementing effective strategies to achieve the goals of inclusive education. Now, AR is not only useful for studying individual subjects or individual students. It can also be applied to the development of new approaches to learning, in particular the concept of STEM (Shapovalov et al., 2018; Valko et al., 2019).

AR technologies can be an effective tool of organizing interaction and collaboration to present learning outcomes. Other studies, such as (Coimbra et al., 2015; Matsokin and Pakhomova, 2020) concluded that AR is particularly suited for teaching subjects that need to form difficult for understanding in the real world concepts (Kravtsov and Pulinets, 2020; Valko et al., 2019). Matviienko (Matviienko, 2015) described his experience in creating a computer museum. He used augmented reality technology to virtualize objects. The author developed an interdisciplinary study excursion in the museum.

The common practice of using AR in education is to create supplementary books. Some didactic aspects of mixed reality books have been studied by Kravtsov and Pulinets (Kravtsov and Pulinets, 2020), Panchenko et al. (Panchenko et al., 2020). When AR is used, books are transformed into dynamic sources of information. Augmented reality technology has made it possible to “revive” its pages (Ranok, 2020). Now this technology is used in cognitive books such as encyclopedias, atlases, books about space, structure of the Earth, dinosaurs, for reproduction of historical events. Gradually, from coloring books and fairy-tales, augmented reality technology is being extended to the production of educational products. That is, they are gradually moving from game technology to learning. For example, students use specialized software for joint study of mathematics, physics, chemistry, geometry (Coimbra et al., 2015; Iatsyshyn et al., 2019; Kramarenko et al., 2019; Matviienko, 2015; Zinonos et al., 2018). These studies have shown the benefits of using AR books as a tool to increase children’s motivation. Books in the AR have also proven to be effective means of concepts formation.

AR technology is developing quite rapidly. As a consequence, research in education does not have time to provide theoretical understanding or develop a systematic methodology for creating appropriate learning tools. We believe that the use of AR technology is a modern trend, and therefore research in this field is relevant and timely.

The *purpose* of this study is to explore the possibilities of using augmented reality technology at school, in particular when teaching computer science.

Objectives of the study are:

1. To analyze the experience of using AR technologies in education;
2. To find out the possibilities of using augmented reality technology in teaching computer science;
3. To experimentally test the attitude and readiness of teachers to use AR in teaching of computer science.
4. To define some STEM projects with augmented reality technologies. Assess opportunities for their implementation in secondary schools

Object of study is the process of teaching computer science in secondary school.

Subject of research is augmented reality technology as a mean of teaching computer science in secondary school.

2 PROBLEM STATEMENT

In the Ukrainian education system, postgraduate institutes are responsible for implementing innovations in primary and secondary schools. These institutions remain an important component in the process of computer science teacher training. This article will describe the experience of trainings organization at the Ternopil Regional Municipal Institute of Postgraduate Education (TRMIPE). The purpose of these training's is to develop teachers' skills for augmented reality application. The article will explore the services and their functionality for the computer science lessons. Augmented reality allows the student to visualize complex spatial connections and abstract concepts. Therefore, with their help, the teacher can develop abilities that are difficult to form in a traditional learning environment (Oleksiuk et al., 2017; Ponomareva, 2021; Spirin et al., 2018; Vlasenko et al., 2019).

Technologies for augmenting reality with digital objects (perhaps not just digital ones) can be conditionally positioned between two polar variants of possible realities: the reality we live in and virtual reality (VR) (figure 1).

Reality is a philosophical term that means what actually exists in physical space, and physical space itself. Virtual reality is the absolute absence of real objects. It is a technically created world that is transmitted to man through his senses: sight, hearing, touch and others.

Quite often, a combination of these realities is called Mixed Reality (MR). Virtual reality can be filled with people, weather, events, and more. If images of these objects are broadcast from the real world, then the result will be augmented virtual reality (AV) technology. At the current level of development, AV technology is virtually unused, but in the future it can be much more impressive than AR and VR.

Azuma (Azuma, 1997) identified augmented reality features such as:

- combining the real and the virtual world;
- interactivity;
- combining the real and the virtual world.

The augmented reality system is the mediator between man and reality. Therefore, it must generate a signal for one of the human's perception organs. Therefore, according to the type of presentation of information in the AR system, they can be classified such as visuals, audio, and audiovisuals.

By type of sensors for the acquisition of data from the physical space there are AR systems:

- Geo-location. They focus on signals from GPS or GLONASS positioning systems.
- Optical. Such systems process the image obtained from the camera. The camera can move with or without the system.

Augmented reality systems can be classified by user interaction. In some systems, the user has a passive role. He only watches the system react to changes in the environment. Other systems also require active user intervention. There he or she can control the operation of the system and modify its virtual objects. According to this feature, the systems are divided into offline and interactive.

Let's look and analyze the program tools that are most appropriate to use when teaching computer science at school. Based on the analysis of articles and sites, we can say that there are very few such applications and services. Therefore, teachers and scholars are looking for ways to use augmented and virtual reality to improve and support school-based learning. But to make the right choice, they need to know the requirements for existing applications and services and the limitations of using them. As the experience suggests, most Ukrainian schools do not have high-end AR or VR devices.

The benefits of AR are the ability to increase motivation, emotional perception of the students' learning content. The highest level of application of these technologies is the involvement of students in the creation of their own virtual worlds. At the same time, teachers should also be interested in implementing such innovations. They should have as little doubt as possible about the capabilities of AR technologies and their own capabilities.

Among augmented reality applications, there are those that can be used in the study of various subjects, not just computer science.

The Quiver application allows the teacher to create coloring books with augmented reality. With the app, students can interact with objects they create. Painted images are transformed on the gadget screen into augmented reality. There is an opportunity to play with animated characters. The teacher can use the Quiver app in the lesson as a tool for developing creative skills or for pupils' reflection.

WallaMe is a platform that can be implemented to integrate augmented reality into the learning process. WallaMe Ltd launched the application in 2015. Using this app is an easy way for both teachers and

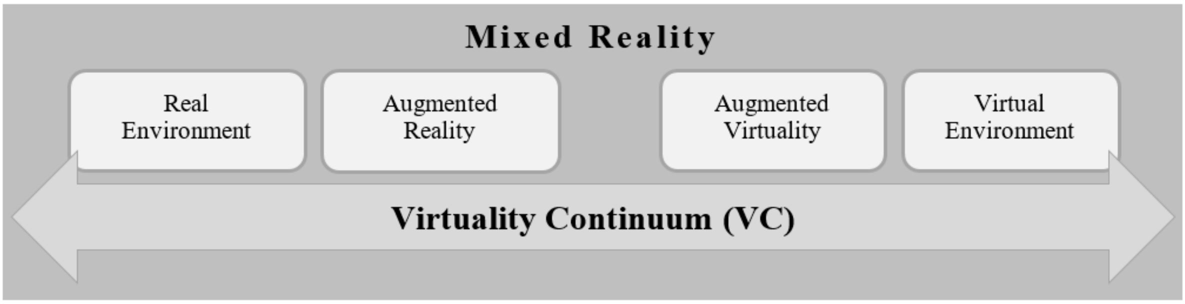

Figure 1: Reality-virtuality continuum (Milgram and Kishino, 1994).

students. WallaMe is a free iOS and Android application. It allows users to hide and share messages in the real world using augmented reality. These messages appear as a result of changing the geolocation of the smartphone. In addition, the WallaMe app provides students and teachers with additional tools such as:

- a library of stickers;
- advanced drawing tools;
- tools for working with text;
- simple and minimalistic graphics and elements of the interface;
- connection to a smartphone camera;
- comment option;
- accessible to all or private messages.

WallaMe allows a teacher to take a picture on a smartphone and leave a picture or message there. The object created in this way is linked to the image and geographical coordinates. Another app user sees a message icon on the map. He or she will only be able to find out it if he points his camera at this wall.

The application can be used in the study of computer science to create knowledge maps or tests in augmented reality. For example, a teacher creates a geotag on a specific computer hardware device. The learner should identify and add text with the characteristics of this device. In the study of programming, students can perform in augmented reality the task of completing a code snippet, determining the values of variables, finding errors. In the case of a positive experience, the teacher can use the application to create integrated tasks, such as web quests (Wang, 2017).

One of the most popular mobile apps is Google expedition. It is an immersive education application that allows teachers and students to explore the world through over 100 augmented-reality tours. In addition, the app offers more than 1,000 virtual reality tours (edu.google.com, 2020). They can be used effectively by teachers of various subjects.

Unfortunately, as of now, only 2 expeditions are available for computer science in AR mode:

- Computers. The tour allows students to learn and explore how different components of a computer function.
- Introduction to Computer Graphics. It covers topics such as: History of Computer Graphic, Creating a 3D World, Modeling, Texturing and Shading, Ray Tracing and Light, Rendering.

Google Expedition provides collaborative learning opportunities. The teacher has the opportunity to download the completed tours and invite students to see them in augmented reality. Unfortunately, creating your own AR Tours with Tour Creator is not currently available. For now teachers can use an external tool such as cospaces.io. The service allows them to create or import three-dimensional models. These objects can be offered to students for using on mobile devices.

CoSpaces.Edu service provides great programming experience. It enables students to learn by doing, using the various tools available with the VR and AR technologies. All features in CoSpaces.Edu can be adapted to fit different class subjects and learning objectives. The platform uses a visual programming language ideal for beginners or gets access to scripting languages for more advanced coding. With its fun Lego-like colored blocks, CoBlocks is the ideal solution for junior pupils. More advanced coders can have fun coding scripts to add interactions and events or even create games (Cospaces, 2020).

The platform enables the collaboration of the teacher with several students. They can work on individual or collaborative projects. Most of these projects these projects can be saved in AR. Augmented Reality lets students project their own creations onto any plane surface in the real world by looking through the screen of their device.

The advantage of the system is the use of single sign-on technology. It integrates well with cloud services, including Google Workspace for Education.

Drezek (Drezek, 2020) uses the CoSpaces service to perform tasks for students such as creating an animal habitat, creating a game about holiday traditions in virtual and augment reality to share with the schools around the world. Michael says that students in own space can experience what they design and program in virtual and augmented reality.

In our opinion, the highest level of implementation of AR in the teaching of computer science is the development of students own elements and scenes in augmented reality. According to (Boonbrahm and Kaewrat, 2014; Cakir and Korkmaz, 2019; Youm et al., 2019) one of the most popular and productive means of achieving this goal is the Unity engine and the Vuforia library. One of the many advantages of Unity is that it is a free game engine that has the possibility to deploy to many different platforms as iOS and Android. This, combined with the Vuforia AR platform, makes it possible to assign a virtual camera in the 3D scene that is linked to an image tracker. This combination can then be deployed to a smart phone or tablet. Finally, it is possible to utilize the camera on the device in order to mix the 3D scene with the camera image (Kjellmo, 2013).

We compared these tools according to the main criteria (type of tool, equipment, interaction with the student, place in training, cost). Table 1 contains a comparative analysis.

In addition to AR services created by IT firms, there are also authoring AR applications to support computer science training. Let's look at some of them.

AR-CPULearn is based application for learning CPU. It was created by scientists of Universiti Kebangsaan (Malaysia). AR-CPULearn was implemented as an exercise activity for computer organization and operating system students in higher education. This applications offer for execution some exercises with overlaid multimedia information. For example, answer a few questions based on a training video; name the main components of the motherboard, explain how the processor and motherboard work (Boonbrahm and Kaewrat, 2014).

The Mixed Reality Laboratory (Bond University and CQUniversity, Australia) is involved in the development of mixed reality applications for solutions to complex pedagogical problems. In our opinion the "Network and ICT modeling" project is the most exciting startup of this lab. The purpose of this project is to use the augmented reality visualization method to help students understand the theoretical model of open systems interconnection (OSI) and its implementation as a stack of TCP/IP protocols (www.mixedrealityresearch.com, 2019).

The application simulates in augmented reality the construction of simple computer networks. This simulation uses a five layer TCP/IP model to visualize how packets are interpreted and distributed. The simulation utilizes augmented reality markers which are detected and tracked in 3D space by smartphones cameras. When students are focusing a camera on the marker then they can see a multiple network devices such as modems, routers, switches, wireless AP etc. These devices can be connected to the network. Visually, this will be shown as lines on the smartphone screen.

The application visualizes packets from devices that generate traffic. This visualization corresponds to the TCP/IP model. The demo shows not only traffic but also individual packages and their headers. Visualization in augmented reality is dynamically transformed as the network topology changes. The application also demonstrates signal conditioning between wireless devices. The student can select any device as the source and as the recipient when transmitting traffic. As a consequence, he or she will see the visualization and model of this process in augmented reality.

3 RESULTS AND DISCUSSION

We continued our research on augmented reality training. The training was conducted at TRMIPE from September to November 2019. Participants of the trainings were 2 groups of computer science teachers (20 people in each group). They could choose augmented reality topics. We used different techniques to teach different topics (table 2).

We have conducted a survey to verify attitude and readiness of computer science teachers to use AR in teaching. The participants of the training filled out a questionnaire. They evaluated AR applications by the factors of frequency and usefulness of their use in training. The questionnaire was based on the usability measurement software (Serdiuk, 2014). The questionnaire contained 12 questions. The answer options were formed according to the 5-point Likert scale. They determined the ratio of the respondents from completely negative (0 points) to completely positive (4 points). This distribution prevented the respondents from making unreasonable choices about the mean of the answer. We avoided questions in the negative form when forming the questionnaire. We also used the Likert scale to determine respondents' age (from 0 points – age over 60 years to 4 points – age 20-30 years). The entire table of respondents' scores can be down-

Table 1: Augmented reality program tools.

Name	Software	Equipment	Interaction	Place	Cost
Quiver	Application	Mobile device	One user	Reflection	Commercial, Free
WallaMe	Application	Mobile device	Many users	Quests, Learning Projects	Free
Google Expedition	Application	Mobile device	Many users	Demonstration, STEM-projects	Free
CoSpaces Edu	Application, Site	Mobile device, PC	Many users	Programming, development	Commercial, Free
Vuforia AR	Application	PC	One user	Development	Commercial
Unity	Application	PC	Many users	3D-modeling	Commercial, Free
Poly	Library	PC	Many users	3D-modeling	Free
SketchUp	Application, Site	PC	One user	3D-modeling	Commercial, Free with a state grant

Table 2: Augmented reality training topics.

Topic number	The name of the topic	Training technique
1.	The concept of virtual and augmented reality	Conversation
2.	Types of augmented reality	Mini-lection
3.	Examples of augmented reality	Demonstration
4.	Checking mobile gadgets for support of AR technologies	Work in groups
5.	Prospects for the use of AR technologies in education	Training exercise, brainstorming
6.	Create your own augmented reality effects	Individual work
7.	Develop a list of required AR models for the computer science course	Collaboration

loaded from the link https://drive.google.com/file/d/1zIS8c0RForHw8KA49qBQGhynQvAcpzTy

To check the internal consistency of the questionnaire, we calculated the Alpha Cronbach coefficient. Its value ($\alpha_{Cr} = 0.73$) can be considered acceptable. We considered the latent indicator of each question to be the average of all respondents' scores. Table 3 shows the list of questions and their respective mean values.

We have selected the following significant average values of respondents' scores:

- less than 1.5 points – the indicator is not almost manifest;
- 1.5-2.0 – the indicator is weak;
- 2.0-2.5 – the indicator is sufficient;
- more than 2.5 – the indicator is strong.

The obtained average values of the indicators are shown in the following diagram (figure 2). Significant values of indicators are highlighted with colors.

As can be seen from the diagram, a weak manifestation is found in indicators related to the readiness and use of AR in the real learning process. However, the study found strong and sufficient manifestations of the indexes regarding the usefulness, motivation for use and pedagogical potential of AR applications. At the trainings we observed the interest of teachers, especially when they saw in AR their own digital world.

Another objective of our study was to determine the dependencies between these indicators. To do this, we used a correlation method. To determine the specific correlation coefficient, we checked the normality of the distribution of each indicator. We have performed the Shapiro-Wilk test of normality. Here are the results of the R-function shapiro.test for all indicators:

- `p-value(UGT) = 0.01297000;`
- `p-value(SUG) = 0.00004502;`
- `p-value(MAR) = 0.00186300;`
- `p-value(CAR) = 0.00386600;`
- `p-value(EAR) = 0.00124000;`
- `p-value(ARI) = 0.00024080;`
- `p-value(RAR) = 0.00066520;`
- `p-value(ARE) = 0.00531300;`
- `p-value(ARC) = 0.00011270;`
- `p-value(PAR) = 0.00019137;`
- `p-value(ARA) = 0.00235700.`

Since the asymptotic significance is less than 0.05, the distribution is not normal. In this case, the Spear-

Table 3: Questionnaire items.

Question code	The content of the question	Average of respondents' scores
UGT	How often do you use gadgets in teaching?	2.38
SUG	How often do your students use their own gadgets in learning?	1.90
MAR	How often do you use AR apps in computer science teaching?	1.80
CAR	How often do your colleagues use AR in computer science teaching?	1.90
EAR	How easy is it for you to learn AR technologies?	1.98
ARI	Using AR in computer science teaching can be interesting	2.43
RAR	I feel ready to use AR	1.83
ARE	AR is entertaining	2.05
ARC	AR used in computer science training can be credible	2.33
PAR	My proficiency level of AR	1.90
ARA	The use of AR is advisable in the study of computer science	2.58

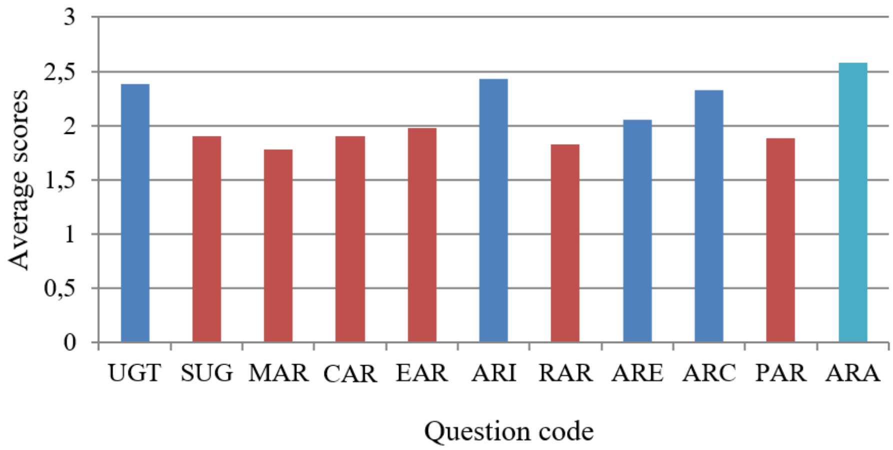

Figure 2: Distribution of indexes.

man rank factor should be used. It is a statistical measure of the strength of a monotonic relationship between paired data. Correlation is the size of the effect. The coefficient determines whether the quantitative factor influences the quantitative response. Its absolute value is usually interpreted according to the following ranges:

- 0.00 – 0.19 – relationship is very weak;
- 0.20 – 0.39 – relationship is weak;
- 0.40 – 0.59 relationship is moderate;
- 0.60 – 0.79 relationship is strong;
- 0.80 – 1.00 relationship is very strong.

Its positive value shows the existence of a direct relationship between factor and response. A negative coefficient indicates the reverse relationship.

We used the R-library "corrplot" to calculate and display the rank correlation coefficients. All correlations are significant at 0.05 level. We considered indicators with a moderate and strong correlation. In the figure 3, they are highlighted in red.

The first line of the table indicates a strong relationship between teachers' age and their experience with AR use. That is, younger teachers are easier to learn AR applications, they are more confident in their ICT competencies. Therefore, they are more likely to use AR in computer science training.

The study found a strong link between the frequency of use of AR technology in teaching computer science and the beliefs of teachers about the feasibility of its use. A positive strong relationship was also found between teachers' proficiency level and the frequency of AR use.

The use of augmented reality by colleagues has a positive moderate impact on the same activities of the interviewed teachers. The Bring Your Own Device (BYOD) approach also helps to incorporate AR into learning. Teachers who are learning to work with AR applications are more positive about the credible data that this technology displays.

In addition, the survey found several indicators that were poorly explained. First of all, there is no significant positive correlation of ARE (Entertainment of

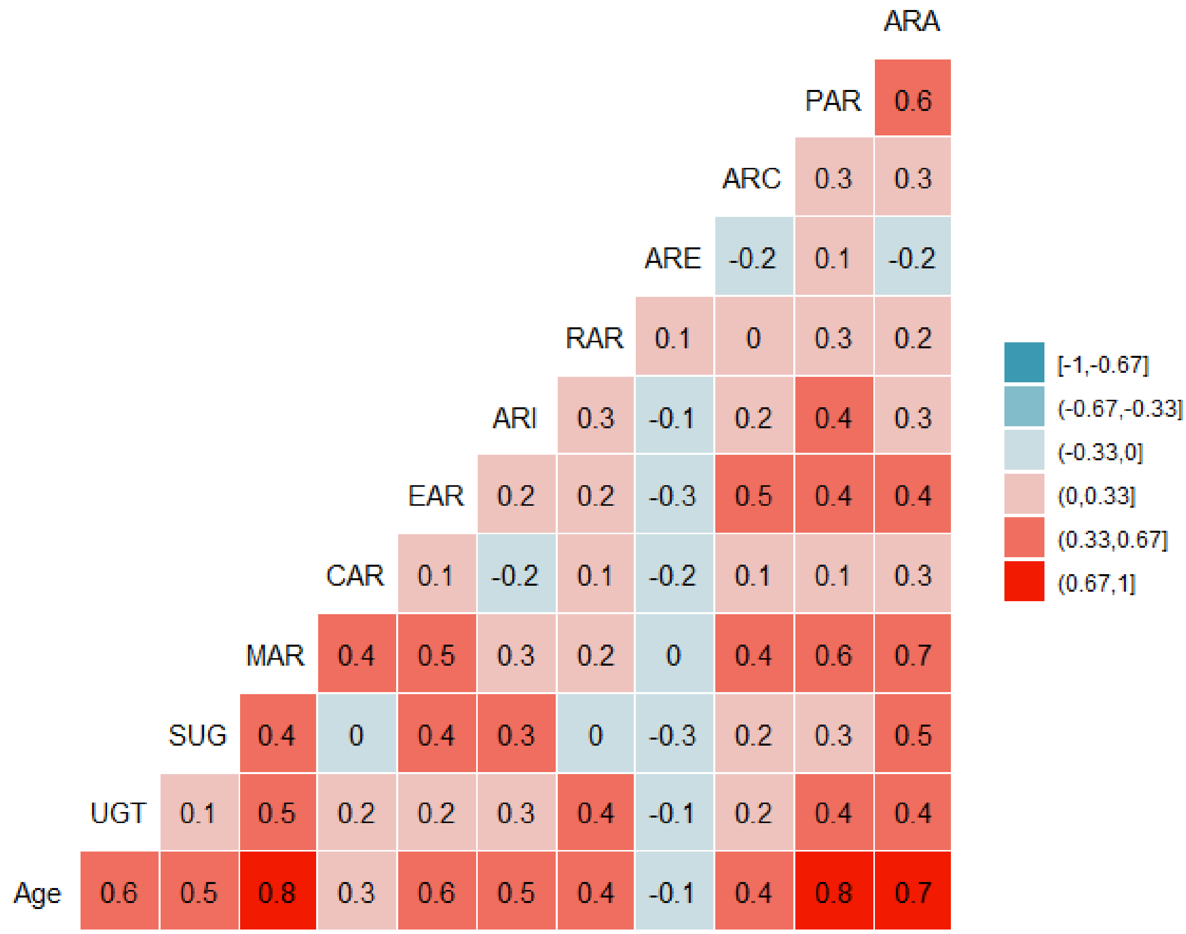

Figure 3: Matrix of plots with a indicators data set.

AR) with other survey questions. This may mean that teachers do not pay enough attention to the gaming approach in teaching. A similar situation was found with the RAR indicator. That is, despite some level of AR using, teachers still do not consider themselves ready for it.

We also found no significant correlation between the use of AR and the fact that these technologies are interesting and motivating. Also surprising is the fact that communication with colleagues has no effect on the readiness of a computer science teacher. In our opinion, these paradoxes are a result of the lack of appropriate methodology. In general, we can say that negative research results require rethinking and further exploration.

Figure 4 contains a matrix of plots for indicators with significant correlation. These plots show the distributions of values for the indicators “PAR”, “MAR”, “ARA”, “CAR”, the corresponding diagrams and the correlation coefficients between them.

4 EVALUATION OF SOME STEM PROJECTS WITH AUGMENTED REALITY

Today, STEM projects are becoming very popular in schools. Their implementation allows you to integrate knowledge from different subjects. Solving real problems determines the practical direction of tasks. At the same time, students generate new ideas and develop their own competencies, such as mathematical, technological, social. Mobile applications with augmented reality allow to increase the interest of modern schoolchildren in the study of natural sciences. First of all, this is possible thanks to advanced multimedia technologies. These tools make it possible to “revive” and clearly represent complex concepts.

We invited teachers to consider and evaluate several STEM projects at the training. In these projects, augmented reality mobile applications were proposed. These applications are free and available

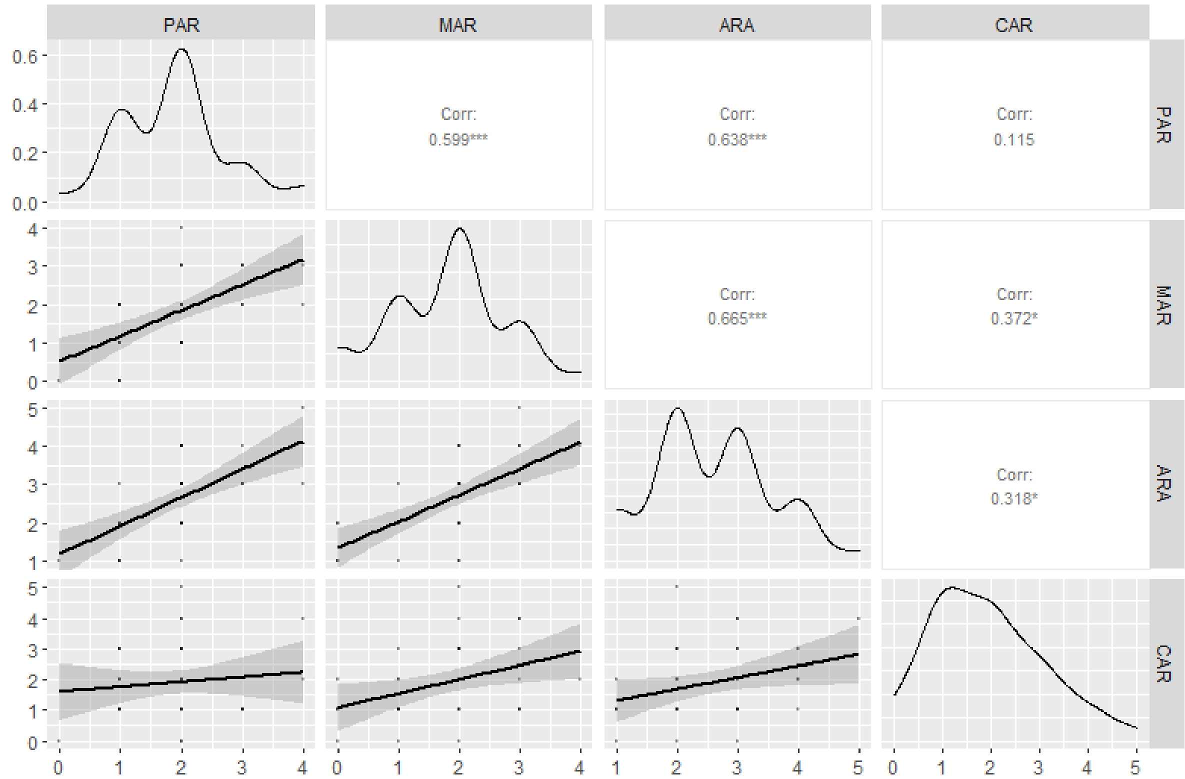

Figure 4: Matrix of plots with significant correlation values.

for download in Google Play and App Store.

Project 1. Skyscrapers. In this project, we used the Skyscrapers AR mobile application to study 3D models of five famous high-rise buildings in the world. Today, engineers use robust materials and innovative schemes to design buildings of this height. So, it would be good for students to implement this STEM project. In computer science lessons, they study augmented reality technology, its capabilities and terminology. In math lessons, children learn to build diagrams. In language lessons, they discuss the project in dialogues and prepare essays on construction technologies. In geography lessons, students can explore the soil for building skyscrapers. In technology lessons, children create models of skyscrapers and design a device to test their own buildings.

Students during the project should find answers to questions such as:

- How to choose a building material?
- How to check whether the manufactured materials meet the advertised specifications?
- How long will the finished product last?
- Are the materials safe to design and use?

Finally, it is advisable to discuss with students what career prospects they see after participating in this STEM project.

Project 2. Da Vinci Machines. In this project, we used a mobile application with augmented reality to study the models of the famous inventor Leonardo da Vinci. This project is related to history, mathematics, technology, art. Students will learn about the biography of Leonardo da Vinci in history lessons. In computer science lessons, they learn to search, collect, process, present data from various sources. The AR application is designed so that children have the opportunity to work with two layouts of pictures-labels: horizontal (the picture is located on the desk) or vertical (on the stand, interactive whiteboard, screen, etc.). The teacher can offer students to study such models as: Helicopter da Vinci, "Self-supporting" bridge da Vinci, Tank da Vinci, Catapult da Vinci.

In technology lessons, it is advisable to organize the practical manufacture and testing of these models. For example, a self-supporting bridge can be made of simple materials, such as ice cream sticks.

With their own catapults, students can explore the mechanical motion of a body thrown at an angle to the horizon, to check the law of conservation of mechanical energy. It is important for the project that children study 3D models in AR applications and compare them with hand-made devices. Shooting distance competitions should also evoke positive emotions in children.

Project 3. Bridges. Today, bridges are built in different shapes, sizes and materials. What makes a bridge the strongest? Project participants learn about this by building simple paper bridges. The children can then measure the maximum allowable weight for each such sample. Students also use the "Bridges AR" application to explore some models.

In this project, important issues for research are such as:

- identification of the main types of bridge structures;
- explanation of the importance of bridges in human life;
- study of the main characteristics of bridges and parts for their
- construction (for example, the distribution of compressive and tensile forces)
- building a model of your own bridge from simple materials;
- experimentally check the maximum load that can withstand the constructed structure.

As a development of this project, it is advisable for the teacher to offer students additional practical tasks. Here are some of them:

- Try to build bridges from other household materials, such as aluminium foil, wax paper or cardboard. Which material is the strongest?
- Experiment with different shapes. What happens if I roll up a sheet of paper in the shape of a tube or a triangle?
- Try making a longer bridge by gluing two sheets of paper together. How long can you skate a bridge before it collapses under its own weight?
- Is bridge design important?
- How safe are different bridges?
- Are there bridges on your way to school or near your house? What type are they?

Such a project can be proposed for a science fair. Children will probably also find interesting stories about professions related to objects of the project.

Project 4. Notable Women. It's no secret that there have always been women in science. They conducted research in various sciences. Some of them made important discoveries.

Studying such stories is important for girls to see themselves as future scientists. With the "Notable Women" mobile application, students will be able to read about an outstanding female scientist, her ideas and research. It is also advisable to create appropriate presentation materials such as info-graphics, videos, booklets, posters, etc.

As a result of presenting these materials, students should see the influence of many women throughout history and think about the thesis that "power is the ability to influence". The completion of the project can be held as a discussion on the question "What is the relationship between power and influence"?

Project 5. The universe. The content of the project is to study the structure of the universe and study astronomy using the Big Bang AR application. This software is the result of a collaboration between CERN and Google Arts & Culture. It will allow students to see the shape of the universe in the palm of their hand, to witness the formation of the first stars, our solar system and the planet Earth. Children will be able to immerse themselves in the mystery of the early universe and watch events unfold around them, for example in their own classroom.

It is advisable for the teacher to ask students to make a model of the solar system and calculate the size of the planets. To see how much space there is between different objects in the solar system, students will have to practice with fractions.

The task of technology may involve the manufacture of models of planets. Children should think about whether it is possible to place "planets" so that their model is proportional to real orbits.

Students can work in groups to solve problems such as:

- search for scale factor;
- calculating the size of the planets;
- creation and processing of graphic 3D models.

Such tasks develop mathematical skills in scaling, and allow a better understanding of space scales. With the help of the Big Bang AR application, the project participants should summarize the concepts and visualize the basic concepts.

Unlike traditional classroom teaching, STEM projects bring students closer to practice, bridging the gap between theoretical problem solving and practical implementation of acquired knowledge. Often in the project the need to use knowledge from different disciplines contributes to the awareness of new material. Career discussions can help students make important connections between the lesson in the classroom and the specifics of STEM professions in the real world.

We conducted some research to understand the attitude of practicing teachers to the STEM projects outlined above. Expert evaluation was chosen as the main method of the experiment. Experience shows that it is effective for assessing the qualitative characteristics of educational methods in various scientific studies (Kuzminska et al., 2019). Decision-making by experts is based on a reliable presentation of the current situation, a correct understanding of the essence of the methodology and the completeness of the characteristics of its components.

We selected 64 computer science teachers as experts. They attended TMPIRE teacher training courses in 2020. To estimate the desired sample size, we used the results of (May and Looney, 2020). To ensure the quality and uniformity of expert assessments, we selected teachers according to criteria such as:

- Work experience more than 10 years;
- 80–90% success rate of learning in TMPIRE;
- The highest national professional category;
- Experience in using augmented reality technologies.

We asked these teachers to evaluate the projects described above according to the following criteria.

Cr1. Relevance of the project as the importance of the project for students. Here we understood the integrated indicator of the project. It determines the possibility of student development through a combination of cognitive, research interdisciplinary activities of students.

Cr2. Realism of the project tasks and availability of execution. The criterion evaluates the possibility of project implementation by students of a certain age group, the compliance of its tasks with the level of preparation of students.

Cr3. Possibility of project development. The integrated indicator involves assessing the prospects of the project through the expansion of research objects, participation in affiliate programs, profit The content of the project is an information component.

Cr4. The criterion should assess the possibility of developing ICT competencies, in particular their skills for the use of augmented reality applications.

The experts ranked each of the projects according to these criteria. The evaluation was performed on an ordinal scale from 1 to 5. One point was awarded to the least significant indicator and five points to the highest significant one. We summarized the results of the survey in the table. To transform evaluation into ranking, we asked experts to evaluate all projects according to the first criteria, then according to the second, third, and fourth. The table is available by the link https://drive.google.com/file/d/1xkuiKZUF33nMYNwnCaQaOSkuErLJXqxb.

The most obvious value of the criterion is its overall rating (average rating), which is determined by all experts. This statement is also true for projects. However, it is necessary to check whether this rating is not accidental. This means that we need to check the consistency of expert assessments. Since the distributions of estimates by all criteria and by all projects are not normal (p-value $< 2.2 \times 10^{-16}$), we should use non-parametric criteria to process these statistics. As is known, the Kendall rank correlation coefficient is used to determine the relationship between only two variables. To assess the agreement of more than two evaluators, it is advisable to use Kendall's coefficient of concordance (W).

Statistical processing of ranking results was carried out using the R language. In particular, we used its libraries such as: nortest, irr, Kendall, DescTools, ggplot2.

To calculate the coefficient W, we used the function:

```
KendallW(tcr1, correct = FALSE,
    test = TRUE, na.rm = FALSE)
```

where

- tcr1 is a transposed dataframe of evaluations of all projects according to the 1st criterion;
- correct is a parameter that determines the need to use the emission correction when calculating W;
- test is a logical indicating whether the test statistic and p-value should be reported;
- na.rm is a parameter to skip empty score values.

The results of the calculation of W for criteria 1-4 are presented in table 4.

Table 4: Generalized data for calculating the concordance coefficient W for criteria.

	Kendall chi-squared	**P-value**	**W**
Cr1	152.79	$< 2.2 \times 10^{-16}$	0.60
Cr2	138.70	$< 2.2 \times 10^{-16}$	0.54
Cr3	157.82	$< 2.2 \times 10^{-16}$	0.62
Cr4	130.93	$< 2.2 \times 10^{-16}$	0.51

To interpret the obtained results, we used the following ranges of values of the coefficient W (May and Looney, 2020):

- 0.01– 0.20 – poor agreement;
- 0.21– 0.40 – fair agreement;
- 0.41 – 0.60 – moderate agreement;
- 0.61 – 0.80 – good agreement;

- 0.81 – 1.00 – very good agreement.

From these data we can reject the zero and accept the alternative hypothesis of the existence of agreement between experts. Unfortunately, we have to state that the assessments of experts on the criteria of realism and development of ICT competencies are less consistent. This indicates a difference in the estimates of this criterion for almost all projects.

We additionally performed the calculation of the coefficient W for projects (table 5). We took into account that the same project received the same points from the experts. Therefore, the "correct" parameter was used in the KendallW function. It corrects the calculation of W if there are related ranks.

As can be seen from the table, the Bridges project was ranked by experts on fair agreement. Instead, DaVinci and Woman received good values of W coefficiente.

Therefore, the sums or averages of expert estimates for almost all projects can be objective indicators of the experiment. Summary table6 contains systematized data of average values of evaluations for criteria and projects.

Figure 5 contains a graphical representation of the results obtained. It demonstrates the distribution of total ratings by all criteria.

The DaVinci project received the highest average value of expert estimates. Teachers consider it relevant, realistic and effective for the development of ICT competencies. According to the survey, the SkyScrapers project turned out to be relevant and promising. The Bridges project also received a high rating for the development of ICT competencies. Despite the overall low score, experts consider the "Notable Women" project to be promising. This may be due to the fact that most of the teachers surveyed were women.

In general, STEM augmented reality projects are an effective tool for organizing students' search activities. The objectives of such projects demonstrate the integration between mathematics, computer science, engineering, history, art. The STEM concept is a source of interdisciplinary innovation in school education. As our experiment showed, the organization of STEM projects with augmented reality aroused the interest of computer science teachers. They found the projects relevant and useful for the development of ICT competencies. We can predict that the use of augmented reality technologies will also interest students and will have a positive impact on their choice of future profession.

We recommend scientists, lecturers, teachers to create more STEM projects. This should help to involve students in interdisciplinary learning to gain real practical experience, the development of lifelong learning skills.

5 CONCLUSIONS

Therefore, innovative ICTs should be used in computer science lessons, as they are necessary and crucial for living in the modern world. Augmented reality is one of the most up-to-date teaching content visualization technologies. Currently, the use of AR in education has been a success. In our opinion, the introduction of this technology will increase the motivation to learn, increase the level of mastering the material. This is also possible due to the variety, interactivity of visual presentation of educational objects, migration of part of students' research work into the virtual environment.

Our analysis of publications on the problem of research has shown that the experience of using augmented reality applications is mostly fragmentarily described in scientific articles and blogs of enthusiasts. Appropriate implementation of AR means in the practice of educational institutions will be done step by step.

It is clear that successful implementation of this technology requires special attention to the system of teacher training and retraining, curriculum development and next-generation textbooks. However, such fragmented use of augmented reality is already facilitating the process of its implementation. Our experience has shown that the developed training courses are in demand in advanced training courses. They are of interest to teachers. The results of this study show that IT teachers have access to computers and mobile devices and have a high level of interest in augmented reality technology.

The study found difficulties in implementing AR such as:

- increasing the time of teacher's preparation for augmented reality classes;
- AR tools are usually application-specific, so learning about different topics requires installing and sometimes integrating multiple applications;
- sometimes AR is perceived by students and teachers as an entertainment game, not as a learning environment;
- development of high-quality AR applications clearly requires the work of professional programmers.

This study has several limitations. The questionnaire was based on self-assessment. Therefore, the

Table 5: Generalized data for calculating the concordance coefficient W for projects 1-5.

	Kendall chi-squared	**P-value**	**W**
DaVinci	153.1	$< 2.2 \times 10^{-16}$	0.80
Universe	80.94	$< 2.2 \times 10^{-16}$	0.42
Bridges	70.72	$< 2.2 \times 10^{-16}$	0.37
SkyScrapers	111.74	$< 2.2 \times 10^{-16}$	0.58
Notable Women	132.19	$< 2.2 \times 10^{-16}$	0.69

Table 6: Final table of expert evaluation.

	DaVinci	**Universe**	**Bridges**	**SkyScrapers**	**Women**
Cr1	3.27	3.59	2.22	4.53	1.39
Cr2	4.58	3.70	2.92	1.91	1.89
Cr3	1.61	1.86	3.17	3.94	4.42
Cr4	4.27	2.27	4.11	2.63	1.73
ProjectSum	13.73	11.42	12.42	13.01	9.43

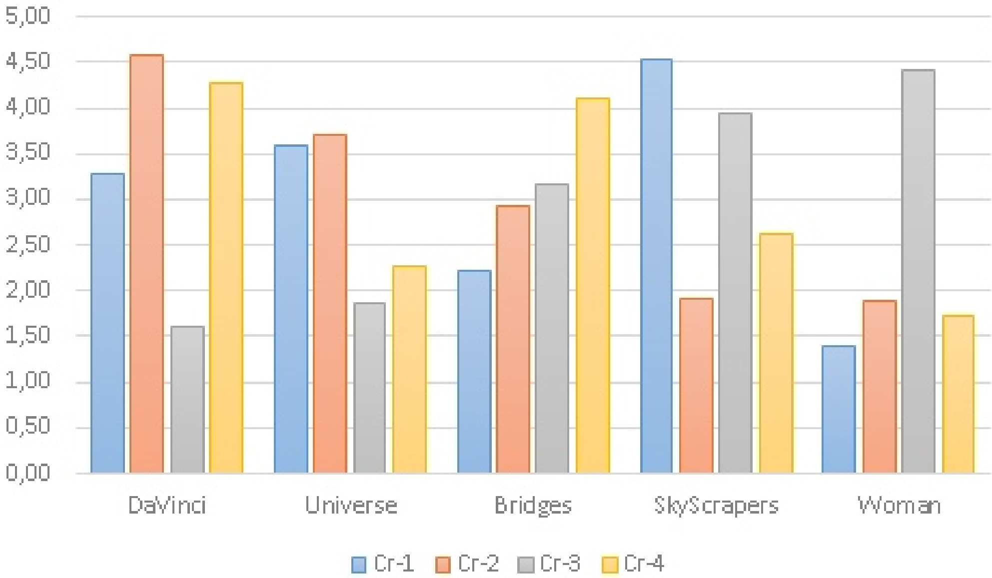

Figure 5: Diagram of distribution of expert assessments according to criteria 1-4.

level of ICT competence and teacher readiness was not sufficiently objectively determined. Also, the degree of use of AR applications has not been measured in practice. In addition, the number of teachers was limited. As a consequence, it is likely that teachers with advanced digital competence participated in the experiment. Expert assessments can be only one of the methods for determining the complexity of the STEM project, and therefore have a recommendatory nature.

There is a need for future research on technical and methodological issues of using augmented reality technologies in school STEM projects. For example, the development of repositories of educational AR-applications to support computer science is currently in demand.

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Comparing Google Lens Recognition Accuracy with Other Plant Recognition Apps

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Keywords: Mobile Application, STEM-Classes, Augmented Reality, Plant Identification, Google Lens.

Abstract: Motivation students by providing personalized researches and using IT during classes is relevant in the frame of STEM approach of education. However, there is a lack of researches devoted to the justification of these approaches. The aim of the research is justifying of the choosing of AR-plant recognition application choosing to provide personalized during both, educational process at school and extracurricular activities. All apps were analyzed and characterized by all processes of interaction of the app with the user. In addition, social environments of the apps and their usage during extracurricular activities described. The didactics of usage of AR-recognition apps on biology classes have been described. To provide usability analysis, a survey of experts on digital education on installation simplicity, level of friendliness of the interface, and correctness of picture processing was conducted. To evaluate the rationality of usage, apps were analyzed on the accuracy of plants recognition of the "Dneprovskiy district of Kiev" list. It is proven that Google Lens is most recommended to use. Taking to account results of the analysis, as alternative Seek or Flora Incognita; however, these apps were characterized by lower accuracy.

1 INTRODUCTION

To date, the introduction of a mobile phone into the educational process is a modern instrument, which provides achieving better results. The usage of a mobile phone during classes provides visualization of educational material, involving students in research, which increases students' motivation for learning (Martín-Gutiérrez et al., 2015; Kinateder et al., 2014). Mobile phone applications compared to computer approaches are characterized by the most promising advantages including mobility of usage, possibility to use both internal and external sensors (not commonly used). The modern educational directions include personalization and research process which may be achieved by using mobile phones (Marienko et al., 2020). However, it was proved that not certain elements of education but a general didactic approach led to significant effect (Shapovalov et al., 2020b). The main concept during which the mobile approach relevant to use is STEM/STEAM/STREAM technology. Those methods include using of both, research (scientific) and engineering methods. To improve the efficiency of them, use of computer software or mobile applications can be used.

The role of information technology in the learning process is widely described (Kinateder et al., 2014; Park, 2011; Clark and Ernst, 2008; Shapovalov et al.,

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2019; Dziabenko and Budnyk, 2019; Kapici et al., 2019; Devi and Rav, 2018).

1.1 Types of Software Which Can Be Used during Education

All software that can be used during the learning process in the application of STEM technology can be divided into desktop applications, mobile applications, and web-oriented technologies. The most perspective of information and communication technology (ITC) to use is augmented reality (Martín-Gutiérrez et al., 2015; Kinateder et al., 2014; Marienko et al., 2020; Shapovalov et al., 2018; Agustina et al., 2019), virtual reality (Kinateder et al., 2014; Potkonjak et al., 2016; Joiner, 2018; Lee and Wong, 2014; Sala, 2014; Hussein and Nätterdal, 2015; Zantua, 2017; Antonietti et al., 2001; Park, 2011), providing of digital environments of education, including computer modeling (Sarabando et al., 2014; Sahin, 2006; Sifuna, 2016; Khine, 2018; Clark and Ernst, 2008), providing of centralized educational networks (Shapovalov et al., 2019; Stryzhak et al., 2019), mobile-based education (Modlo et al., 2019), modeling environments (Dziabenko and Budnyk, 2019; Jong et al., 2014; de Jong, 2019; Kapici et al., 2019) providing of education visualization by including YouTube videos (Chorna et al., 2019), 3D modeling and printing, etc. Comparison of the most used in the education process software is presented in table 1.

So, using of mobile phone apps during educational process is characterized by arrays of advantages such as multi-capabilities, interaction with students in their research and visualization on the educational process. Detailly, mobile apps can be classified as measuring apps, analyzing apps, image recognition and classification apps, course platforms, VR and AR-based apps. Based on functions of apps, they can be deviated into the following categories:

- training (course) platforms;
- measuring apps;
- measuring apps;
- video analysis apps;
- applications that analyze images and classify them;
- augmented and virtual reality (AR and VR) apps.

Comparison of different mobile apps categories is shown in table 2.

Apps-identifiers characterized by high potential to especially in biology classes due possibility to provide personalized researches. Today, there is a range of mobile applications that identify wildlife. Such apps are insects- (for example, Insect identifier Photo), animals- (Dog Scanner), mushrooms (Fungus) and plants-identificatory (Flora Incognita, PlantSnap, Picture This). Some apps provide identification of few type nature (both, plants and animals), for example Seek. In our opinion, most promising are applications that provide analyzing of the static objects of the nature (plants and mushrooms). It is due to lower requirements to the camera. So, they don't require high-expensive smartphones and it can be used widely during the educational process, almost in all schools.

1.2 The Problem of Plants Identification

There are about 27,000 species of flora in Ukraine. Such biodiversity requires detailed description and study. Also, natural conditions are constantly changing, and this causes changes in the species composition of biocenosis. Both aspects indicate that there is a problem with plant identification. One of the basic principles of pedagogy is the principle of a nature experiment. For a modern child, a mobile phone with Internet access is its natural environment. So, training should be carried out in an environment, where the mobile phone should become a full-fledged learning tool.

Some apps can be installed on the student's mobile phone for free to determine the species of plants, their morphology, the range of distribution, and more.

There are about 10 applications that can be used to identify the plants. Most common of them are LeafSnap, Seek, PlantNet, Flora Incognita, PlantSnap, Picture This, Florist-X (in Russian), What is a flower (in Russian), Manager of houseplants (in Russian). These applications can be divided into three gro plant identifiers that can analyze photos (Google Lens, for example, PlanNet, Flora Incognita, PlantSnap, Picture This. ups, such as:

- plant identifiers that can analyze photos (Google Lens, for example, PlanNet, Flora Incognita, PlantSnap, Picture This.
- plant classification provides the possibility to identify plants manually. The plant's classificatory commonly contains pictures and information about plant kind. But the quality of analysis, in this case, will depend on the user's knowledge and skills which may be hard for both teachers and students. Their use in biology lessons within the STEM approach has considerable potential because it allows to lean the plant morphology. However, its efficiency depends on the knowledge of user which may be lacked in case of pupils (for example, Florist-X and What is a flower).

Table 1: Comparison of the most used in the education process software.

Type	Web-oriented	Mobile applications	Desktop applications
Installation	Not required	From official stores or using application file	From official stores or installation files
General requirements	Compatible Internet browser for all features support	Compatible version of Android, iOS or another mobile operating system	Compatible version of Windows/macOS/Linux or another desktop operating system
Facilities	Modeling, calculation, visualization, video presenting	Modeling, calculation, visualization, video presenting, AR, measuring using both internal and external sensors, photo analysis, AR, VR	Modeling, calculation, visualization, video presenting, using additional external sensors
Main advantages	Cross-platforming, no installation required, low device space usage	Huge possibilities, mobility of usage	Stability and variation of applications
Main disadvantages	Limited opportunities, may not start correctly depending on the platform, lack of individualization	Needs technical updates which may be expensive (in two-three years may be required to buy new phone)	Lack of individualization, the lesser effect of increasing motivation during STEM-education

Table 2: Comparison of the most used in the education process software.

Type of application	Description	Examples
Education platforms	These platforms allow the teacher to create instructional content, communicate with students, give them assignments and check them out automatically	Google Classroom, Prometheus, Coursera, Microsoft Office 365 for Education
Measuring applications	These sensors and their software are already built into mobile phones	Measure, AR-ruler, Smart Measure, Lux-meter, Accelerometer, Magnet Field Meter
Image analysis apps	It allows you to measure distances, angles, perimeters, areas, and calculate with this data.	ImageMeter
Image recognizing and it's classification applications that analyze images and classify them	These mobile applications allow you to identify species of plants and animals using photos	Identification, Mushroom, Identify, Shazam, Dog Scanner, Identify
VR and AR-based apps	Allow virtual travel, get a spatial image of the training material.	Minecraft Earth, IKEA Place, Ideofit, Lego Hidden Side

- plants-care apps that remind water of the plant or change the soil, which characterized by the lower potential compared to other types of application (for example Manager of houseplants).

Taking into account all advantages of plant identifiers, they were used as an object of the research. It was proven that Google Lens provides high efficiency in plant type and species identification (Shapovalov et al., 2020a). Google lens can provide analysis of real-life objects in AR and provide additional information using neural network algorithms. A few articles have devoted to Google Lens that proves its actuality to use (du Plessis, 2015; Syawaldi et al., 2019; Devi and Rav, 2018). However, some apps-identifiers may be more specialized and may provide better efficiency of the identification.

Despite the great specialization of other applications, hypothesize the research is that Google Lens is the best plant analyzer due to larger database, better algorithmic of analyzing and teaching of AI using Google crowdsource app (500 000+ installation).

Therefore, the purpose of this article is to analyze existing applications, that can be used in teaching biology both in the classroom and in the field.

2 METHODS OF ANALYZING

To provide an analysis of the usability of applications related to plant identification, a survey of experts on digital didactics was provided. The main criteria were installation simplicity, level of friendliness of the interface, correctness of picture processing. Each criterion was evaluated from 0 to 5 (as higher than better). Those applications which were characterized by average evaluation more than 4 were used to further analysis on quality of identification due taken to account fact usage of the application during the educational process, where it will be used by students and teachers, both potentially with not the highest level of ICT competence.

Analysis of quality of identification was provided by a simplified method compared to our previous research due aim of this paper to obtain a general state on application plant identification accuracy. To provide it, 350 images from the list of plants of the "Dneprovskiy district of Kiev" were taken to provide analysis. The key from the "Dneprovskiy district of Kiev" plant classification was used as control. To analyze the data, tables with names of the plant as lines and as names of app in columns has created. For each successful identification at the intersections "1" has put and for each unsuccessful "0" has put (see an example in table 3).

Table 3: Example of the table of apps analyzing.

The name of the plant	Flora Incognita	PlantNet
Prunus armeniaca (Apricot)	0	0
Jasione montana	0	1
Ageratum houstonianum	0	1
Chaenomeles japonica	0	0
Amaranthus	1	0
Ambrosia artemisiifolia	0	1
Amorpha fruticosa	0	0
Anemo	1	1
Anemonoides ranunculoides	1	0
Anisanthus tectorum	0	0

Finally, all obtained results, including both, general usability evaluation (survey) and results on identification quality were compared with results on Google Lens to summarize information and achieve a general and final state in this field.

3 RESULTS

3.1 Analysis of the Interaction with Apps

General characteristics of the apps. The apps databases are significantly differing. The lowest number of plants in database is included in Flora Incognita (4800 species) and the highest is included in PlantSnap (585,000 species).

In additions, the apps databases differ by presence of species based on geographical locations. For example, Flora Incognita's database is very limited geographically and contains only German flora; Opposite, PlantNet's data is geographically very wide and contains flora of Western Europe, USA, Canada, Central America, Caribbean islands, Amazon, French Polynesia, including, medicinal plants, invasive plants, weeds.

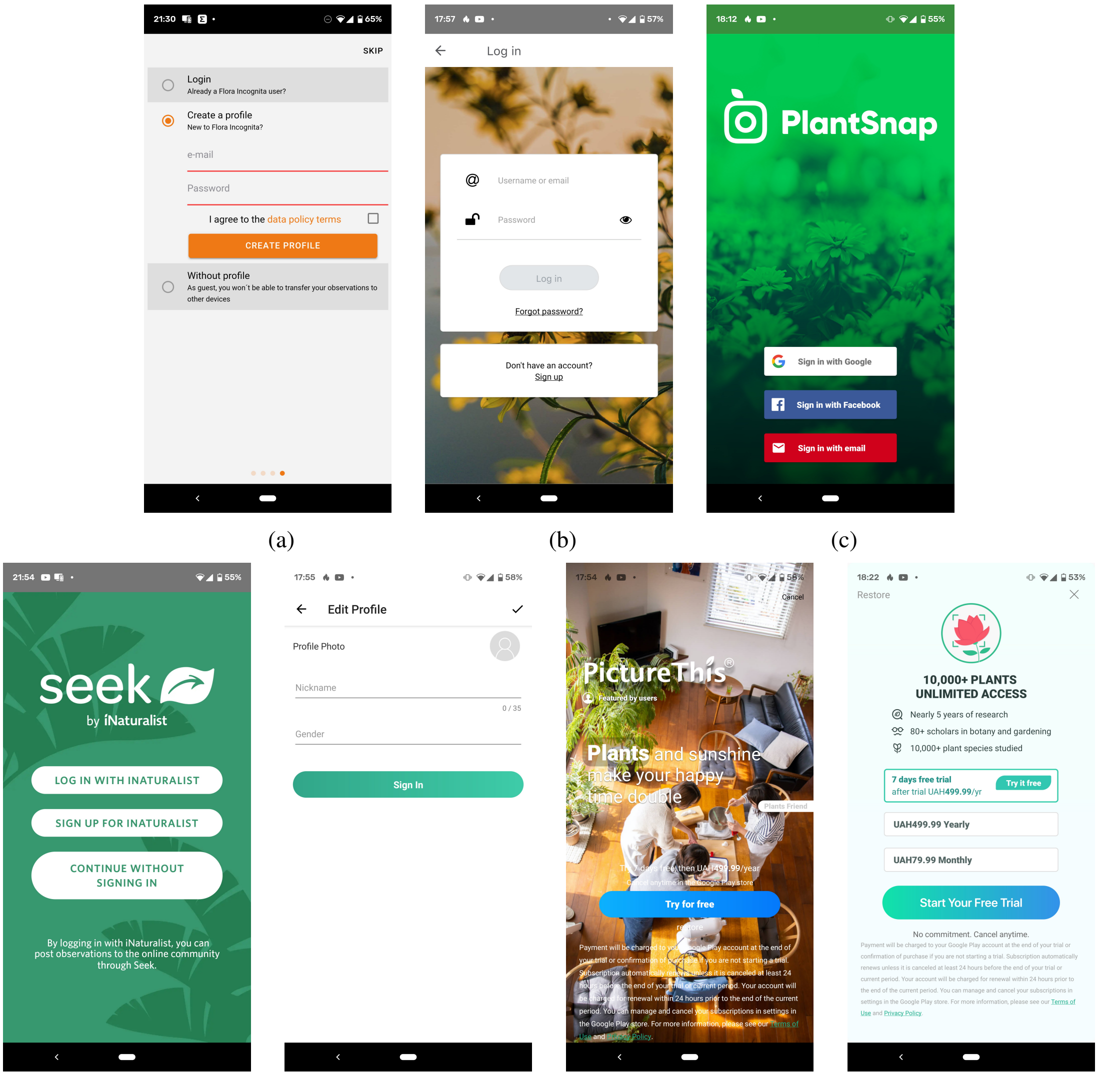
Login procedure and instruction. For education, the login procedure is very important due its related to the safety of student's personal data. On the other hand, login possibility is important to save achievements, progress, and communications which motivates student.

Only LeafSnap doesn't use the additional account et al (it automatically connected to Google account). Almost all apps request their own account. Seek requests Inaturalist account (to connect with social network Inaturalist). Apps such as FloraIncognita starts from account creation page; PictureThis starts from payment page which may be a disadvantage for using by pupils. Login process of Flora Incognita, PlantNet, PlantSnap, Seek, Picture-This, and PictureThis's aggressive advertising is presented in figure 1.

The detailed video instructions are sent to the e-mail only using PlantSnap app (English voice and Russian subtitles). Other apps provide instructions in app. PlantNet does not have Instructions et al. Instructions of PictureThis's are very simple. LeafSnap's help is not displayed at the first start; it is located in a specific tab. Instructions in Flora Incognita (a), PlantSnap (b), PictureThis (c) LeafSnap (d) and Seek (e, f) apps is presented in figure 2.

Data and photo input process. According to botanical science, the algorithm for determining a plant includes: establishing the life form of the plant (tree, bush, grass); then studying the vegetative parts of the plant (leaves, stem). In addition, generative organs (flower or fruit) analysis is useful to determine a specific species name. Flora incognita and LeafSnap are provide addition of different part of the plant's pictures. The mechanism of processing can differ. For example, Flora incognita process photos of different parts of the plant; PlantNet are provides photography and then choosing of the plant part (analyzing only one photo).

Geographic location is very important to identify many species. Picea omorika and Picea abies are very similar species, but Picea omorika only in Western Siberia and Eastern Bosnia and Herzegovina. Seek,



(a) (b) (c)

(d) (e) (f) (g)

Figure 1: Login process of Flora Incognita (a), PlantNet (b), PlantSnap (c), Seek (d), Picture-This (e), and PictureThis's aggressive advertise (f, g).

Flora Incognita, LeafSnap, PlantNet requests geolocation access during the first start. If the algorithm for determining the plant in the application includes the definition of life form, photographing the vegetative and generative organs, as well as the geographical location of the object, the algorithm has evaluated as completely correct. If the application of the plant is based on the analysis of one image in a single click, the algorithm has evaluated as simple. The interface of different apps photo and data input is presented in figure 3.

In general, all apps are free, but PlantSnap limits identifications by 25 plants per account per day. The programs can request or a single photo of the plant or photos of different parts of plants (PlantNet). LeafSnap provides automatic detection of the part of the plant presented in the photo. In general, all programs provide the possibility of both, making a real-life photo or uploading of photo made before.

Identification results. All apps (except PlantNet and Seek) provides information on the determined plant. All data on the plant is very structured in all apps and displayed for example in style: "Genus: Fucus".

FloraIncognita, PlantNet, PlantSnap provide interaction with other sources. Both, general sources such as Wikipedia and very specific sources such as Plants for a Future are used to interact. The most interactive is Plant net. It provides links to Catalogue of Life, Plants for a Future and Wikipedia Flora Incognita,

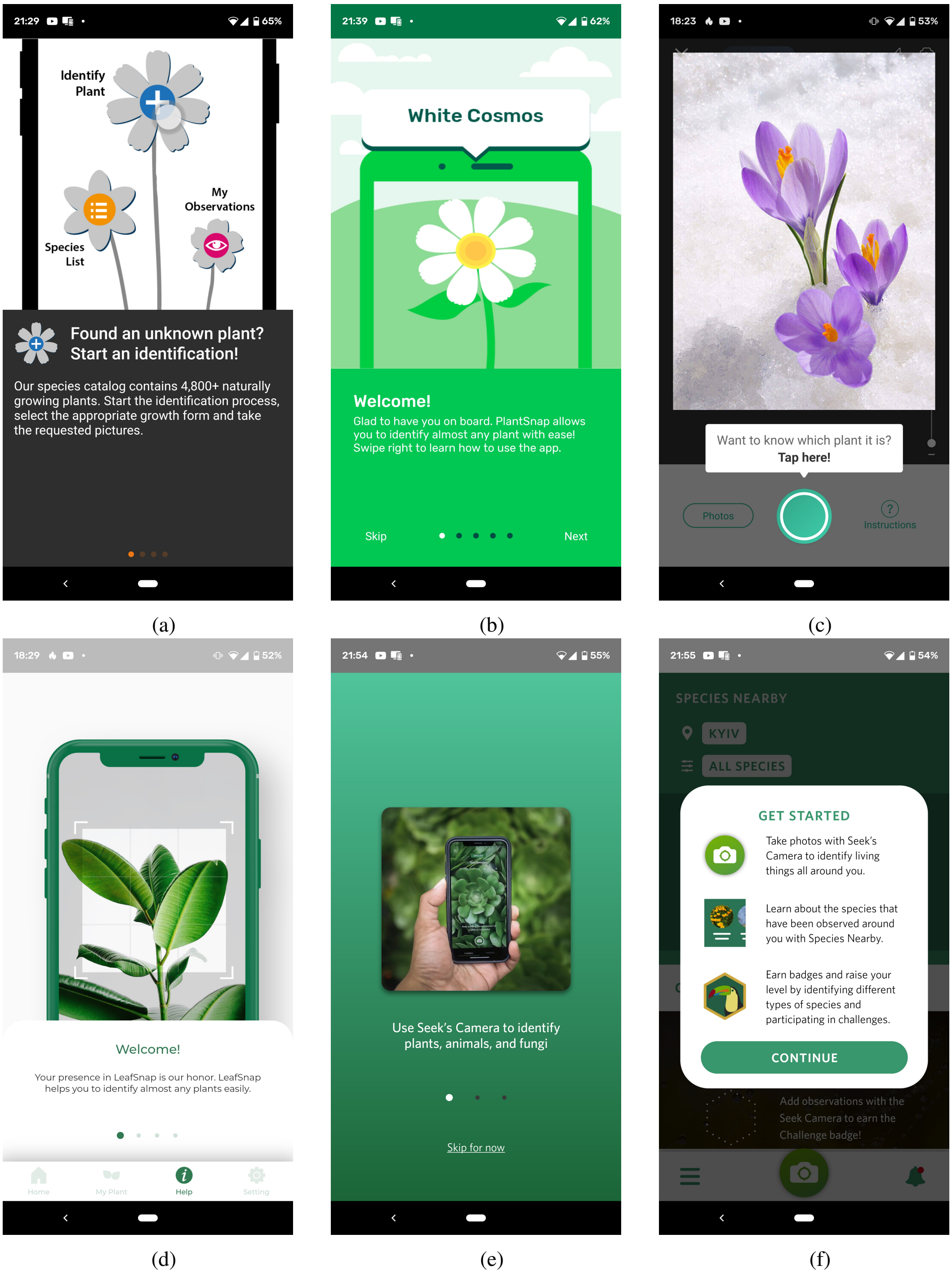
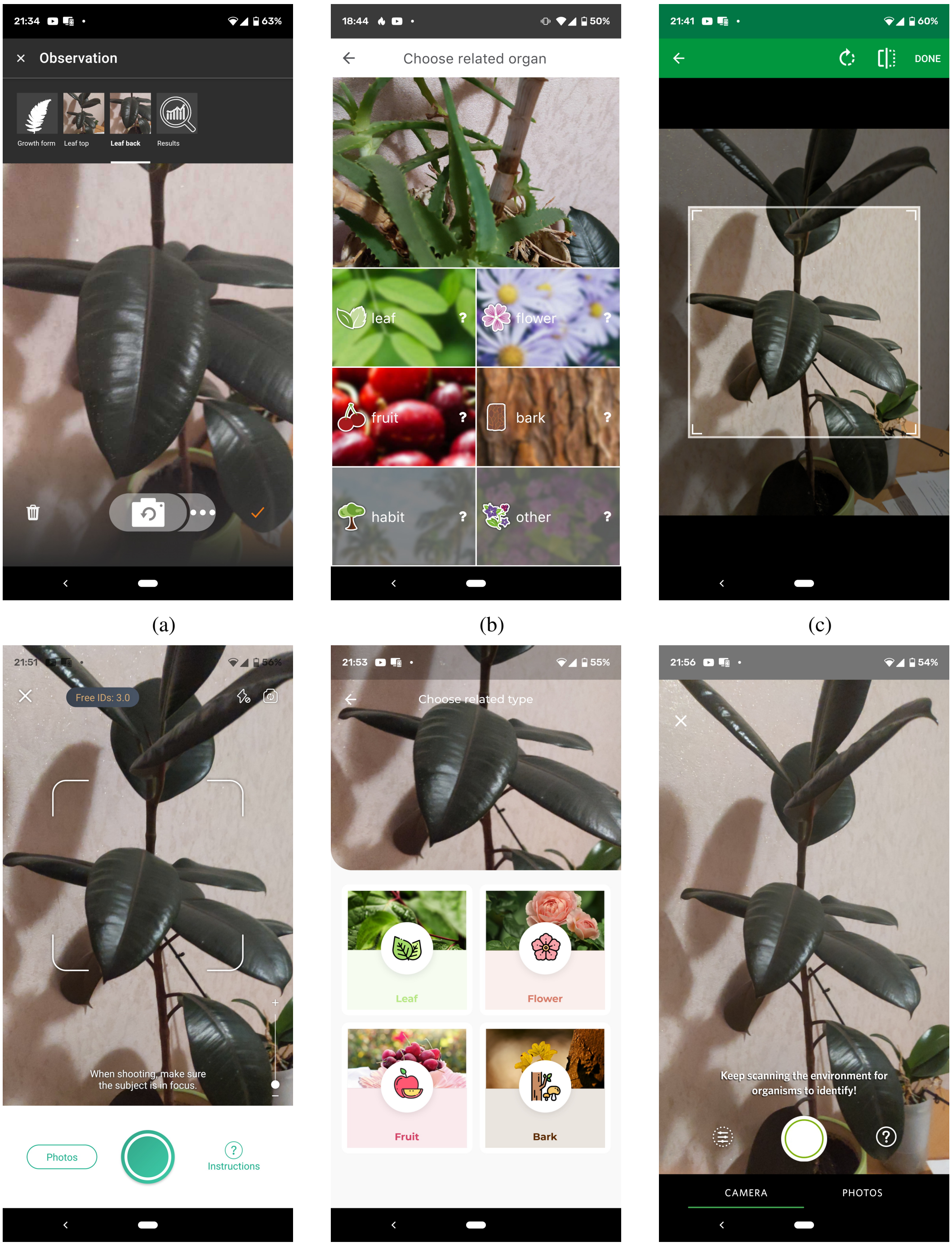


Figure 2: Instructions in Flora Incognita (a), PlantSnap (b), PictureThis (c) LeafSnap (d) and Seek (e, f) apps.

and in the case of Russian interface provides the link with site www.plantarium.ru (figure 4). Comparison results of mobile applications that can analyze plant photos are presented in table 4.

There some very specific functions during identification:

- PictureThis can provide auto diagnose of plant's problem on pests and diseases (figure 5);
- PlantSnap finds the plant at amazon and provides an infographic on solar activity, water usage and activation temperature.



(a) (b) (c)

(d) (e) (f)

Figure 3: The interface of photo and data input of Flora Incognita (a), PlantNet (b) PlantSnap (c) PictureThis (d) LeafSnap Seek (e) apps.

3.2 Infrastructure and Social Environment

Some applications have their own approach to provide complex research of nature. Those features are very useful to increase the motivation of students to research nature. It's worth noting that the most developed environment is in Seek used iNaturalist application (developed by California Academy of Science and National Geographic). Which delivers to

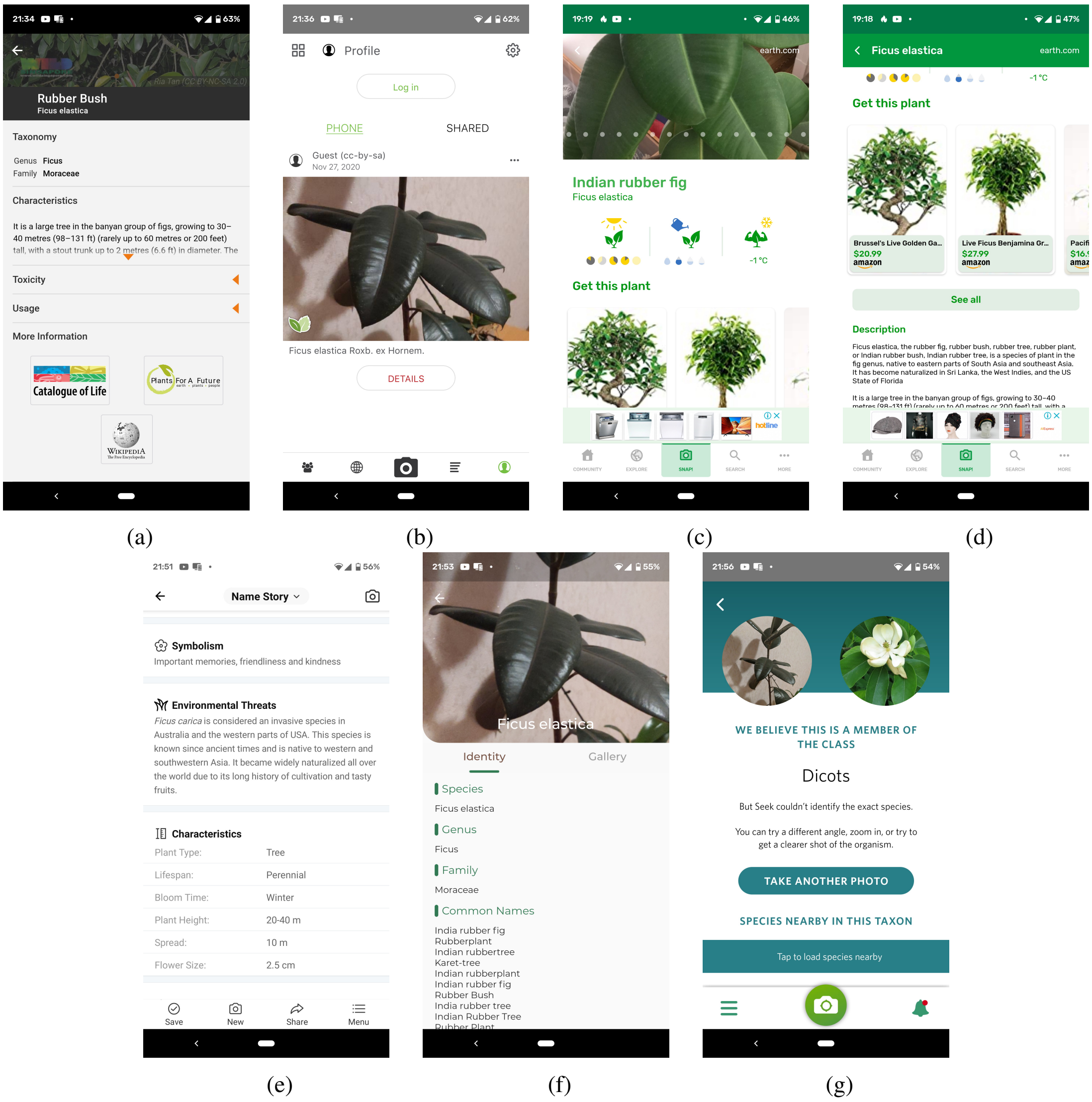


Figure 4: Data on identified plant Flora Incognita (a), PlantNet (b), PlantSnap (c, d), PictureThis (e), LeafSnap (f), and Seek (g).

students and teachers' powerful systems of different instruments.

Photo sharing and communications. PlantNet provides the feed of photos to identify, shared by other users of PlanNet. The information in the feed is divided into classes "identified", "unidentified" and "All"-filter (displays both, identified and unidentified). The items in feed with an "identified" filter will display already identified plants by users and "unidentified" will display not-identified pictures updated by users. The most perspective is using "unidentified" feed which may be useful in a few cases:

- To help with identifying of the plant
- To train own identification skills by providing identification of pictures of others
- To share thoughts in the field of botanic, communicate with other researchers, and to provide social science networking.

Personal journals. The first instrument to motivate is personal journals of observation and identification. This is a very common feature. For example, Flora Incognita has tab "My observations"; PictureThis has "My garden"; Leaf snap has "My plants". However, some apps do not provide explicitly personal journal. For example, PlantNet saves just the history of observations.

Projects and social. Seek provides collaboration by providing projects. Users can find and chose projects they like and join be involved in them. It's worth note, that the app is very widespread and there

Table 4: Comparison results of mobile applications that can analyze plant photos.

App title	**Plants amount in database**	**Correctness of the analyzing process**	**Links with other information services**
Flora Incognita	4800 (only German)	The analysis algorithm is correct	Links to Catalogue of Life, Plants for a Future and Wikipedia. Flora Incognita with Russian interface provides links to the Russian site www.plantarium.ru
PlantNet	21920	The analysis algorithm is completely correct	Only the name of the plant. Includes elements of social networks (by sharing plants student found and subscriptions). It contains links to Wikipedia.
PlantSnap	585000	The analysis algorithm is simple.	Has own description. Provides searching on Amazon to buy it.
Picture This	10000	The analysis algorithm is simple	Provides very structured information (including type, lifespan, height, flower diameter), care aspects, usage of the plant.
LeafSnap	No data	The analysis algorithm is correct. Determining includes evaluation of health state (healthy and unhealthy).	Contains links to Wikipedia, Pl@ntUse, Global Biodiversity Information Facility.
Seek	No data	The analysis algorithm is the simplest. The achieves are given for users after some successful identifications	Has no detailed description, but propose "species nearby in this taxon".

are even projects in Ukraine. The interfaces of project selection and concrete project interface are presented in figure 6a.

Achievements. The Seek-identification app provides a significantly different approach to increase students' motivation. It provides achieves for each plant students found which motivates students to get new and new researches from time to time. The effect of achievement affects the brain as exaltation and people want it again and again. This is used in games to motivate students to play again. In the case of Seek, some factors will motivate students to research nature.

The iNaturalist propose observing of plant and animal kinds student can find nearby. This feature is activated by the "Exploring All" function and choosing "My location". Also, based on location students can use Missions which provides quests for students to do, for example, to find "Rock Pigeon". So, students can observe nature nearby in general to study it and the program will stimulate students by completing the missions. The Exploring All and Missions functions are presented in figure 6b,c.

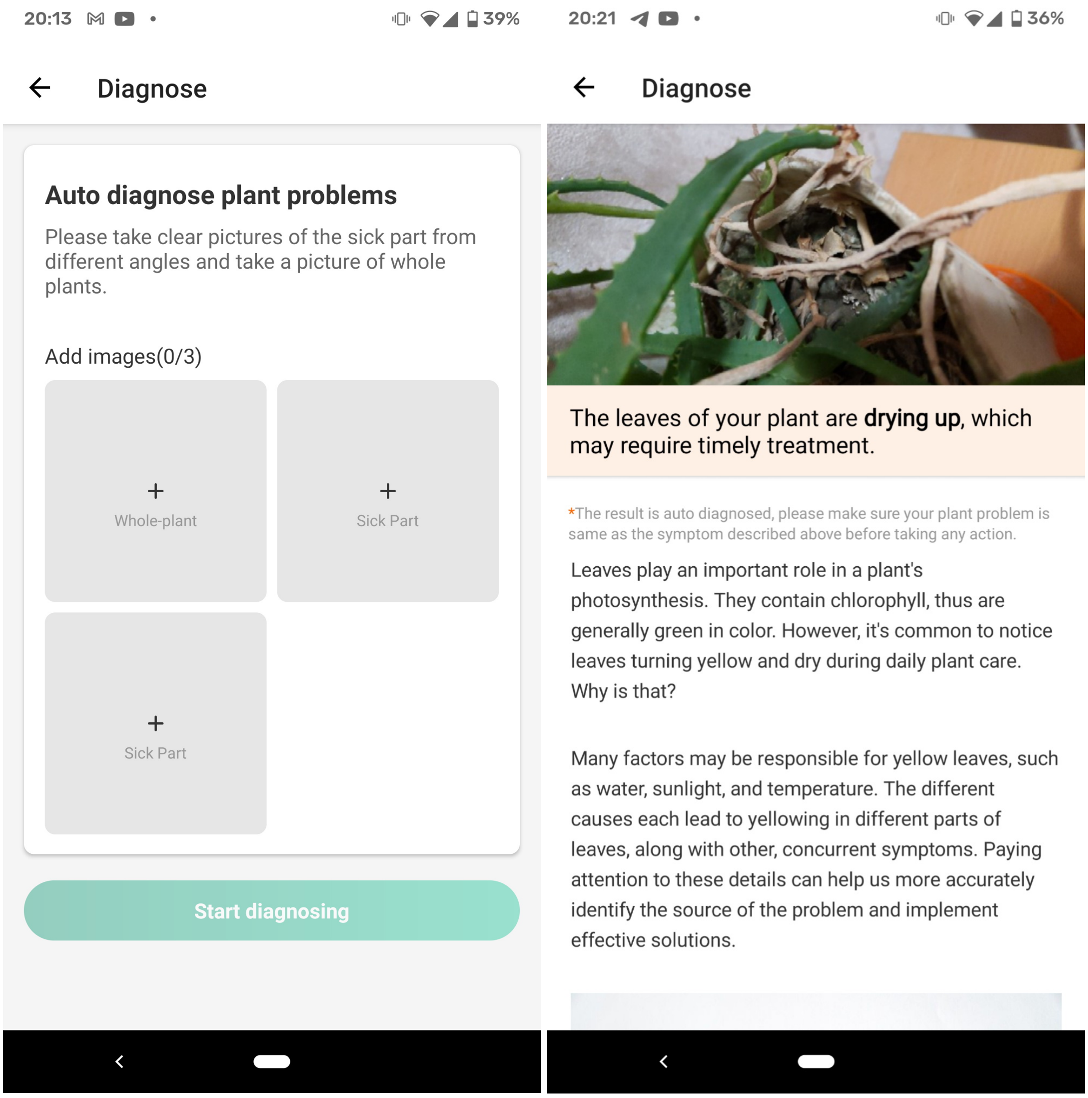
3.3 Analysis of Application Identification Accuracy

PlantNet is the easiest app to install. Also, pretty easy to install are Google Lens, LeafSnap and Flora Incognita. Apps Google Lens, LeafSnap, Flora Incognita, Seek to have the simplest interface. Google Lens, PlantSnap, PictureThis, and PlantNet are characterized by the most uncomfortable process of identification which can be complicated for teachers. Results of detailed analyses on plant identification applications are presented in figure 7.

In general, Google Lens, LeafSnap, Flora Incognita, PlanNet, Seek has evaluated as most usable and they were detailly researched. However, the total number of points each of the applications received is presented in figure 8.

The most accurate apps are Google Lens with 92.6% of correctness of the identification. Flora Incognita provides correct identification of 71% of cases; PlantNet – in 55%; Seek – in 76%. In our previous work, we demonstrated that Google Lens does not differentiate native species from Ukraine. It seems that Seek, PlantNet and Google Lens mostly use data of American and European kinds of plants to training the neural network and they have missed under identification of specific Ukrainian's kinds of plants. Flora Incognita was characterized by significantly different specific of analyses; it may be due to Flora Incognita uses a Russian database (similar to the Ukrainian region). This may explain a higher percent of identification accuracy of Flora Incognita, compared to PlantNet. Results on analysis quality of apps which are identified plants are presented in figure 9.

From the point of view of botanical science, the



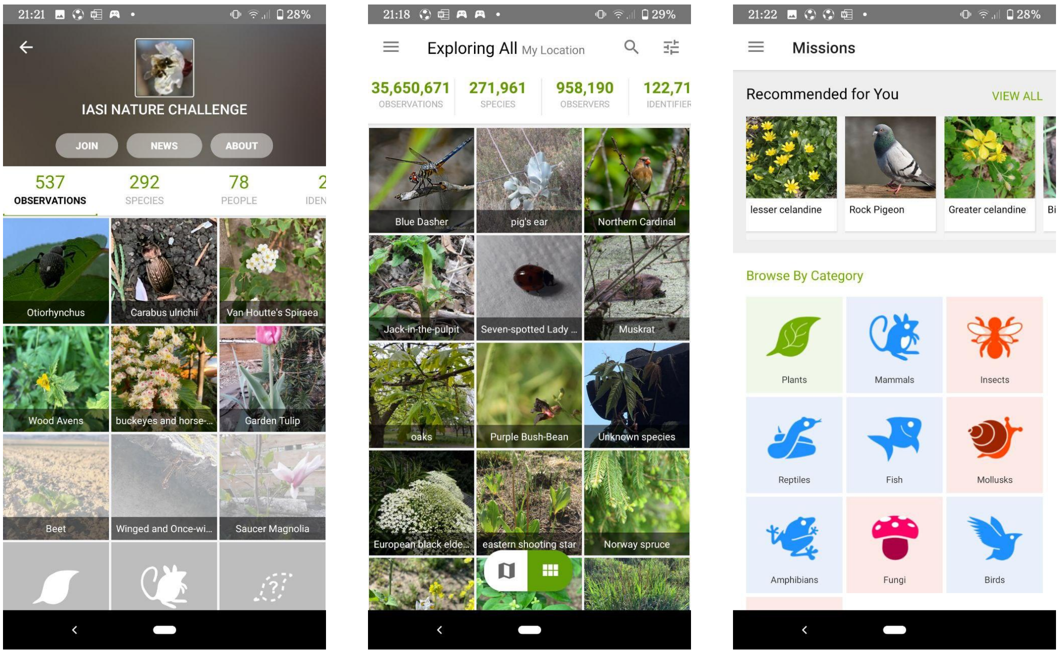
(a) (b)

Figure 5: PictureThis' plant's auto diagnose on pests and diseases function: photo input interface (a) and the result of the analysis (b).

possibility to add different parts the plants and choosing of the plant's type and geolocation access must affect the identification process correctness. However, taking to account the results of the experiment, applications with a simple algorithm definition (analysis of a single image) more accurately identify plants. It seems that internal algorithms of identification (due to higher statistical characteristics of neural network) and fullness of database is more important than correctness of data input or taking to account of geolocation.

So, Google Lens is characterized by the highest quality of analysis which may be due to the better recognition algorithm and the most trained neural network. However, it still may be relevant to use other applications in case it will be characterized by significantly higher parameters of use. To evaluate this, a similar survey as used for other plant identification applications was used for Google Lens. Google Lens has the most intuitive interface, is the most easily loaded, and gives the most accurate definition result and therefore is characterized by the highest general evaluation with 4.6 points of interface analysis. This is significantly higher than marks for other apps.

Therefore, Google Lens is the most recommended app to use. Talking to account, results of usability analysis, and quality of analysis, for those students and teachers who do not like Google Lens app, it is



(a) (b) (c)

Figure 6: The Exploring All (a), Missions functions (b) and concrete project (c) functions.

possible to use Seek or Flora Incognita, but Plant-Net can't be recommended to use due to low accuracy which may provide up to half of incorrect analyzing results.

3.4 Advantages of using Mobile Phone Application in the Educational Process

In our opinion, the use of mobile applications that identify plants during the education process has the following functions:

1. *Creating a learning environment.* Even in the works of the classic of pedagogical thought M. Montessori, it was proved that the environment should develop the child. Mobile applications to a greater or lesser extent create such an environment. For example, Seek stimulates the child to search for new plant objects, manages the process of photographing plants, provides links to additional information about the plant, creates its own synopsis for the child, rewards the child with "achievement".
2. *Cognitive function.* Only 70 hours are allotted to study all plants in Ukrainian schools. There is very little time. Mobile applications allow students to learn about the diversity of the plant world.
3. *Training function.* Due to the limited number of teaching hours, the teacher cannot focus enough on the developed practical skills, such as determining the life form of plants (bush, grass, tree, vine). Such skills are developed as a result of repeated training. Some applications, such as Flora Incognita, request a definition of life form. And this contributes to the formation of this skill.

The use of mobile applications promotes the development of students with the following competencies:

1. Competencies in the field of natural sciences, engineering, and technology (Gil-Quintana et al., 2020). When using mobile applications, students gain experience in the study of nature.
2. Environmental competence (Morkun et al., 2018). Some applications, such as Seek, explain the rules of behavior in nature.
3. Information and communication competence (Kuzminska et al., 2019). The use of mobile applications allows students to demonstrate the safe use of technology for learning.
4. Lifelong learning competence (van den Broeck et al., 2020). The use of mobile applications teaches students to find opportunities for learning and self-development throughout life.

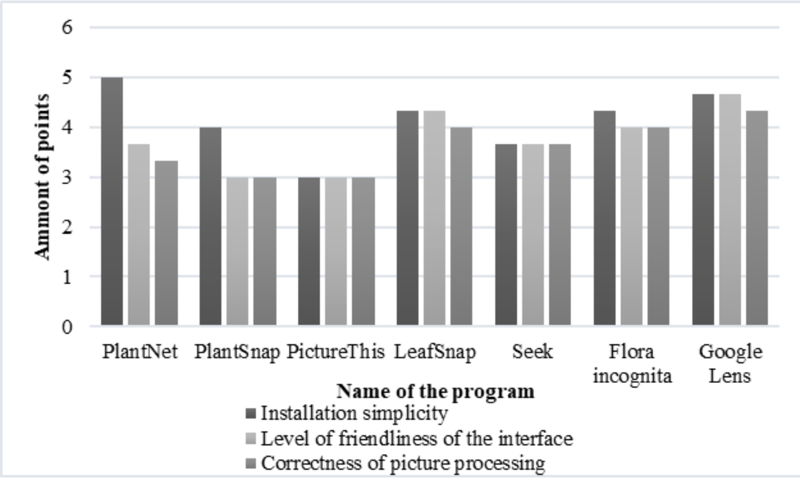


Figure 7: Results of detailed results on plants identification applications usability analysis.

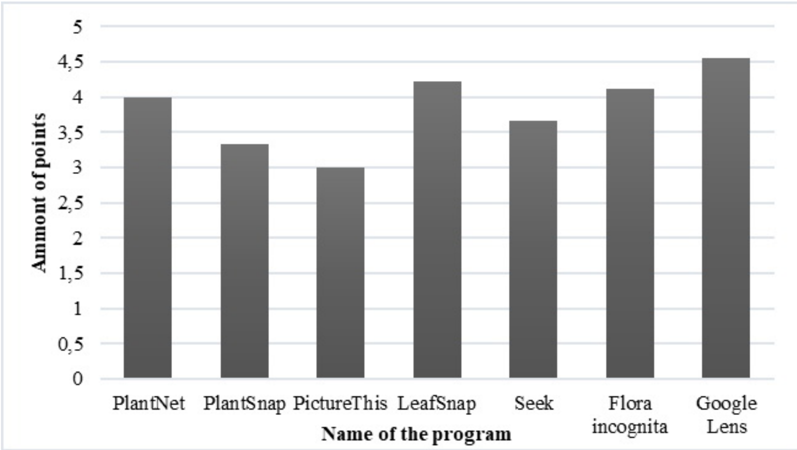


Figure 8: Integrated results on the usability of plants identification applications.

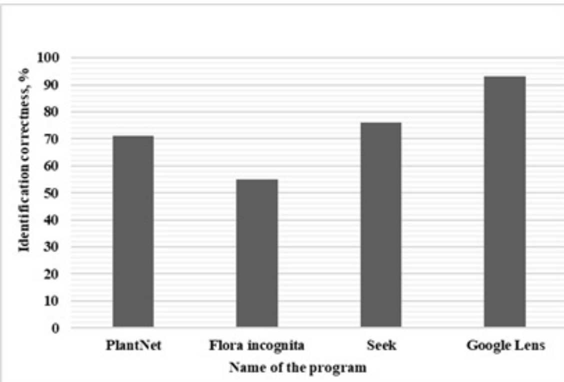


Figure 9: Results on analysis quality of apps which is identified plants.

4 CONCLUSION

Apps related to plant identifications can be referred to as those which can analyze photos, devoted to manual identification, and apps devoted to plant care monitoring. LeafSnap, Flora Incognita, PlanNet, Seek are the most usable plant identifiers apps during STEM-based classes.

It is shown that Google Lens characterized by the highest mark of usability compare to PlantNet, Flora Incognita, and Seek. In addition Google Lens has the highest accuracy of identification rate (92.6%). Seek and Flora Incognita has significantly lower accuracy of identification rate 76% and 71%, respectively. PlantNet provides correct identification only in 55% of case which is significantly and can't be used during education at all. Therefore, Google Lens is the most recommended app to use during biology classes.

However, for those students and teachers who do not like the Google Lens app, it is possible to use Seek or Flora Incognita.

However, Google Lens provides only identification without ecosystem. The Seek mobile application can be used as a complex learning environment. It includes communications between naturalists, achievement system for motivation of the students and other advantages.

In general, it is proven that using of AR-based identification programs characterized by positive effect on education process and provides development of the competencies.

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Construction of an Education Model of Natural Disciplines' Students in the Distance Learning Conditions

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Abstract: For a number of reasons, in particular the introduction of urgent quarantine measures, a temporary change is taking place in the format of full-time studies on distance learning. This requires a quick reorientation of the teacher and students to use educational solutions to provide remote access to teaching material. The article studies the requirements for building a distance course in order to quickly adapt full-time education to distance learning. The features of the organization of distance STEM education are determined. The pedagogical and technological aspects of supporting distance learning STEM are established. The problems that may arise during the organization of distance learning are analyzed and models for overcoming them are considered. An example of constructing a course in accordance with established requirements is given.

1 INTRODUCTION

Distance education is an important factor in acquiring special competencies and a sufficiently powerful resource in the form of online learning skills (not just communication) for further career development of both students and teachers (Kuzminska et al., 2019).

The advantages of distance learning are obvious: to study anywhere and anytime, to determine the amount of information to be processed in a certain period independently, the opportunity to obtain quality, relevant knowledge, learning simultaneously in several areas or combining with work and more. But the effectiveness of these benefits must be ensured by a well-prepared course with different activities. The materials for such course are significantly different from the materials of the full-time course, where the teacher takes into account the characteristics of the audience that listens to him, can supplement the material with clarifications, make an analogy, emphasize the features. Distance courses are planned and prepared for a long time, have several iterative changes. The differences between a quality distance learning course and its hybrid replacement by "emergency" distance learning are described in (Hodges et al., 2020). So the issue of effective transformation of the educational process, which would ensure the construction of education in conditions of limited access to educational institutions, is relevant.

Distance STEM education has the prospect of going beyond traditional educational institutions, providing equal opportunities for students to master modern research skills (Sharko, 2017). Therefore distance STEM education can be considered as an alternative approach to learning that can provide solutions to the problems of science and mathematics learning. However, although the number of studies on distance education has been growing recently, the study of the possibilities of distance STEM education is insufficient. In addition, there is the issue of ensuring permanent access and effectiveness of distance STEM education.

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2 LITERATURE REVIEW

The issues of distance education are sufficiently covered in scientific research. The study of the experience of developing distance learning courses has shown that the issue has a fairly wide range of solutions in organizational, methodological and resource areas.

In Ukraine there are scientific schools exploring the possibilities of distance education and the princi-

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ples of its organization. Works by Kukharenko and Oleinik (Kukharenko and Oleinik, 2019), Vakaliuk et al. (Vakaliuk et al., 2021), Yahupov et al. (Yahupov et al., 2020) and others devoted to the development of distance learning methodologies and the creation of distance learning systems. The issues of effective organization of distance learning and distance learning technologies are devoted to the works of Franchuk and Prydacha (Franchuk and Prydacha, 2021), Kravtsova et al. (Kravtsova et al., 2020), Kushnir et al. (Kushnir et al., 2020), Petrenko et al. (Petrenko et al., 2020), Polhun et al. (Polhun et al., 2021), Zinovieva et al. (Zinovieva et al., 2021) and others.

The organization of a distance STEM training course should notice the following features:

- Scientific approach to the study of the environment – the issues studied and researched by STEM education are among the phenomena for which it is necessary to develop a theory and find an answer about their essence, to give them an explanation.
- Availability of experimental and laboratory work – environmental studies provide empirical data that needs to be analyzed and explained.
- Data processing and analysis – research data are usually presented in tables or graphs and require visualization, interpretation and statistical processing.

Consideration of these features in the organization of a distance course of STEM education can be considered from the standpoint of two main aspects:

- Pedagogical – refers to understanding the principles of organization of STEM student training, the ability to apply research methods in future professional activities. Includes the desire to support different types of interactions in the learning process (Chi and Wylie, 2014; Osadchyi et al., 2019). This aspect defines learning as a social and cognitive process, not just as a matter of information transfer.
- Technological – mostly, refers to recommendations for the use of technologies, in particular, robotic, biochemical, programming environments; selection of technical means that best meet the solution of professional tasks; developing the structure of the course and its content and supporting the learning management system, creating multimedia, determining the content to be covered.

Ensuring a scientific approach to environmental research by students sometimes faces problems if the distance learning course has not noticed pedagogical principles and provisions. For example it could be finding the right information for research. Lewis and Contrino (Lewis and Contrino, 2016) conducted a study of students' online courses and determined that among the most common models of information retrieval by students for educational purposes are:

- Misconception about the research process. Most students chose a linear research model, i.e. they added materials to their work using keywords and direct links, using them as "facts". The search for already adapted information to the requests and needs of students is conducted, and the set of information and its analysis is not analyzed. However, research projects must contain a critical understanding of the information, which requires combining different sources of information into an abstract idea expressed in their own words. The use of linear research models, the authors note, can lead to the use of unreliable information as a "fact".
- Misconception about the semantic search for information on the network. Instead of entering keywords and phrases, students often used direct questions and waited for answers online. The authors note that this model is easily adjusted by learning using a variety of sources of information, including statistics, directories, and research reports of a scientific nature.
- Finding a single source for research or hoping that the teacher will simplify their search and provide everything they need to complete the task.

The lack of students' readiness to search for information and scientific approach to research independently requires to change the organization of their search activities and pay more attention to adjusting the process of designing a distance course so that it contributes to the development of their independence skills. One of the ways to overcome such problems, the authors see in the creation of special interactive sections of the course, instructions on how to search for information. The course itself can also include dynamic links to databases where you can quickly and efficiently find the material you need.

To address these issues, the University of Plymouth has developed an ACE framework – adaptability, communication and equity – to manage decision-making and professional development planning in the context of distance learning (DeRosa, 2020). Each of the frameworks has three levels of distance learning organization: at the level of teaching, at the level of course organization, at the level of the educational institution.

- Adaptability.
  - At the level of a task tutors can set up more nasty task doing terms for the students, because it is clear that they will face difficulties or uncertainty, and it is possible to join students to creating tasks or let them choose tasks from several variants.
  - At the level of a course you can set courses allowing students to pick up the available online and full-time options, as well as to consider the circumstances, and to break the programs on the smaller modules, which can be set up in different modalities depending on different scripts of technical availability of distance learning.
  - At the institutional level it is possible to acquire technology and infrastructure based on the needs of the tutors and students and to provide culture in the university which would help students not to not to continue studying despite difficult circumstances.
- Linking.
  - At the task level tutors can create a task, giving students the opportunity to bring their work to communities, for whom such help would be useful or important, and to understand Internet not just as a channel for exchanging but like a portal which connects studying students.
  - At the course level you can connect an open mind from the reality of life while crisis by asking students to see the links between their abilities and needs. You can use open platforms and give to the masses the corny servants and to prevent the demands of done work using them.
  - On the basis of the mortgage it is possible to reserve additional help from the designers of the studying materials for tutors support. There is also a need for additional help in integration at the training courses of the ways which help to establish the progress in the community, for example, including examples of local and global real life problems' solving in the teaching context.
- Availability.
  - At the task level, tutors can learn the basic principles and universal design tools for learning to ensure the availability of the course as much as possible, and it is allowed to propose a number of advertising channels, so that students could take part with any technology at any time.
  - At the course level, you can quickly go to free educational resources to ensure the availability of the text in the course and reduce cost of the teaching materials.
  - On the basis of the mortgage, it is also possible to set the basic information about the resources and to pay attention of the community to the studying program, and to ensure that the integrated support of the basic education requirements is provided.

The technological course building aspect of distance learning has its own rules. Whereas distance learning course is the supremacy of electronic content, there is the possibility of organizing its elements in relation to the rules used in functional design. These recommendations were made in (Davidson et al., 1999):

- Simplicity – studying is not guilty of "pushing", but "leading" after itself (Malamed, 2015). Each question in a topic can be represented or complemented by short videos (5-10 minutes), overmotivating (motivational) events or by awards (badges). Create a library of "micro lessons". You may be able to compose in the right sequence and to pick it up easier
- Familiarity – each theme must rely on the forefront knowledge, perhaps the model of analogies or journalistic method can be used, which is closed by practical tasks. Analogies see one or more points of similarity between two other things. For example, it can be a part of the function of a cell and a factory (sciencenetlinks.com, 2021). But the analogy method using must have a point, where analogy may be destroyed (Aubusson et al., 2006). The journalistic method is using: breathtaking headlines, teasers in the menu, informative graphics, motivational phrases or history for the completion of the course, which will reflect the essence of the course (Veglis and Pomportsis, 2014).
- Accessibility – the course may not only have enough links on additional resources, but also the doing terms, variants of consulting with the tutor, the possibility of asking questions to classmates or a tutor. Directions are also an important element. Students need strict instructions how to move forward and what progress they achieved.
- Flexibility – the course can be adjusted to the choice of task-doing tools, or the material learning algorithm or doing time independence with meeting the deadlines. Flexible studying program: in the individually determined studying environment student is a doer in creation of flexible studying program defined by a student: students make a studying map and the instructors are like a compass (Hase and Kenyon, 2007).

- Questions directed to the studying and discussion which follows after the questions – that orients students and works as the mechanisms, which help the students to understand the course, to make the idea clear and contribute individual and group reflection.
- Feedback – is a prerequisite for successful learning, the course should provide constant communication about the tasks performed and the results of actions. This allows students to evaluate the results of their work and be more motivated for further study. Assessment should include measurable forms of assessment of understanding the content, determining whether the student has achieved the desired competencies (Hase and Kenyon, 2007, 2001). One example is the use of student assessment by other students, followed by the publication of reviews and discussion. This helps to critically comprehend the evaluation criteria and the presented material, as well as to evaluate one's own achievements (Kushnir et al., 2013).
- Safety – students should feel comfortable taking the course, knowing that they can return to the study of the topic, repeat the material passed, retake the test. Assessment, discussed and defined by students, improves their motivation and involvement in the learning process, as well as makes students feel more protected from the teaching control of their learning process (Canning, 2010).

But despite the sufficient attention of scientists to the problems of building distance learning the issue of distance STEM education and the study of the peculiarities of its organization remains unresolved. One of the advantages of distance STEM education is its accessibility not only to teachers, students, but also to everyone, from scientists, technicians, mathematicians and engineers, to ordinary people who want to study or improve their skills, or can not go to institutions. education due to restrictions (e.g., quarantine).

The *purpose* of the article is to clarify the pedagogical and technical features of educational approaches to building a model of distance STEM education for students of natural sciences.

3 RESEARCH RESULTS

The basis of STEM education is the integration of natural-mathematical and engineering areas of education. The natural component provides a context for combining the study of different disciplines. The engineering component is a unifying category that contributes to a better study of science and mathematics. But integration must take into account their different epistemological characteristics (Herschbach, 2011; Sanders, 2008; The PEAR Institute: Partnerships in Education and Resilience, 2019; Williams, 2011). When planning and building a model of STEM education, these characteristics must be taken into account to preserve the integrity of each industry.

The model of distance learning should correspond to the model of preparing students to study STEM disciplines. It takes into account the relationship of such components as: value-motivational (worldview, the formation of a system of personal development); content-organizational (formation of conceptual connections between theory and practice, planning the study of fundamental disciplines, creating a field of interaction); applied cognitive-activity (implementation of project activities: independent reflection, analysis, work with the teacher); evaluative reflexive-analytical (study of best practices, development of innovations).

The purpose of the system of preparing students to study STEM disciplines is the formation of worldview, which is the result of value-motivational system of personality development (Osadchyi et al., 2020a). Any activity is the result of the action of "value" regulators, which determine the motives and behavior of the individual. Based on the value attitude to technology, the following requirements can be distinguished (Sipiy, 2018):

- awareness of the place and role of technology in human life;
- effective use of equipment (competent, rational, timely, effective;
- safe use (both for yourself and others);
- environmental consequences of use.

The system of preparing students for the study of STEM disciplines is based on didactic and pedagogical principles of teaching and their system integrity:

- the principle of accessibility and awareness of cognitive activity, which provides the actualization of scientific knowledge and activation of cognitive activity through the differentiation of educational tasks and the use of modern teaching aids;
- the principle of scientificity, as a basis for the fundamentalization of knowledge and the formation of the content and organizational component of the model of personality-oriented system of student training. The leading idea of this principle is not the simplification of "scientificity", but the

provision of knowledge that corresponds to the objective reality, in accordance with the age and knowledge levels;

- the principle of systematization, as a basis for the integration of disciplines in order to form logical thinking and a holistic scientific career of the world, taking into account the already formed ideas about the functioning of the environment;
- the principle of linking learning with the needs of real life, as a basis for the formation of skills in demand in the XXI century (Gray, 2016);
- the principle of student-centeredness and personality-oriented learning, as the appropriate direction of the educational process from the needs and level of development of the applicant, through the construction of an individual educational trajectory, in order to implement the tasks of STEM education;
- the principle of emotional participation, as a basis for further involvement in solving educational problems and project activities related to real life situations. The leading idea of this principle is the formation of a value-motivational component of the model of personality-oriented system of student training;
- the principle of cooperation and mentoring, as an opportunity to organize teamwork and support continuity in the system of knowledge transfer.

Formal features of the structure of students' preparation for the study of STEM disciplines define (Valko, 2019):

- the existence of an educational environment, part of which are professional communities that adhere to the norms of introduction of new technologies in the professional activities of students, and is a center of support and dissemination of innovation;
- the presence of disciplines in training, the principle of organization of which is based on integration and project activities;
- availability of scientific problems, the solution of which is based on the integration of scientific methods and innovations into educational activities;
- availability of tools and technologies that will ensure the use of innovative approaches.

The concept of preparing students for the study of STEM disciplines is based on the following methodological approaches: personality-oriented, competence, integrative, axiological, activity.

Personality-oriented approach is the basis of the educational process and determines the forms, methods and means of developing the professional qualities of the student, gaining their own experience. It is closely related to the axiological approach and embodies the student's subjective choice of forms, means, and methods of teaching in future professional activities. Therefore, the issue of proper organization of personality-oriented educational process is gaining importance, in order to stimulate important patterns of life of students. Behavioral models, in the context of STEM education, are the ability to choose their own educational trajectory and be active in the application of STEM technologies.

The *competency approach* directs the process of professional training to the formation of the student's readiness and ability to effectively use external and internal resources (informational, human, material, personal). This approach allowed identifying the components of student training and presenting them as a holistic system of professional, personal and social orientation.

The *integrative approach* is part of the process of fundamentalization of the system and performs the function of system integration of all components as a whole, taking into account the interconnectedness of all components of student training (Semerikov, 2009).

The *activity approach* serves not only as a basis for practical training of students, development of its cognitive forces and creative potential. It can also be a criterion for choosing possible areas of activity and influence the forms, methods and means of cognitive activity.

The *axiological approach* builds the value-motivational component of the student training system. It defines the guidelines of professional activity and contains social, psychological and ethical principles of behavior, which are related to the integration of technology and research into the educational process, determining their pedagogical value.

Based on these provisions, we can formulate the task of professional training of students to study STEM disciplines as the integration of these components, which are expressed in the formation of his skills and abilities to:

- independent construction of teaching your subject using modern technological and engineering knowledge with the help of modern technological tools;
- preparation of the individual for the decision of global questions with application of technological decisions in the course of training and being based on innovations in the field of technologies;

- identify trends in the modernization of world technologies and their impact on educational activities,
- involvement of students in research activities and management of their project activities using innovative technologies;
- dissemination of innovations and knowledge about them in the professional circle and in everyday life.

We will distinguish between different levels of formation of the value-motivational component depending on the activity that underlies such a division, and, consequently, the purpose of such activities. The initial level is characterized by activities aimed at forming an environment of communication and developing interest in the study of STEM disciplines. The next level is based on quasi-professional activity, the value of which is determined by the degree of conscious use of STEM technologies. The third level is characterized by awareness of the value of knowledge through the prism of scientific and technological picture of the world and readiness for such activities. The final level is the formed need and ability to transfer experience, knowledge, values in the process of communication.

The purpose of the *content and organizational component* of the system of preparing students to study STEM disciplines is to form conceptual links between theory and practice, planning the study of fundamental disciplines, creating a field of interaction between participants in the educational process. The structure of the unit is compiled in accordance with industry standards, educational programs and curricula: technical and fundamental disciplines, special elective courses and participation in extracurricular activities. Accordingly, an educational environment for STEM oriented learning should be formed, which would ensure the implementation of this unit. Resource components of the content-organizational stage are software and hardware, educational and methodological support of the educational process and influence the formation of the educational environment of STEM oriented learning.

The content and organizational component of the system of student training is determined by the plan of studying fundamental disciplines and the formation of a knowledge base for further study. It is formed under the influence of both objective and subjective factors. Objective factors are the educational regulatory framework, these are: industry standards, updated educational programs, curricula of specialties. The subjective ones include cognitive activity, the choice of which depends on the student himself: special elective courses, master classes, extracurricular activities. Each of these factors is crucial for meeting the requirements for student learning outcomes and indirectly affects the formation of their professional behavior. These factors can both promote and hinder the formation of self-determination and training.

The *cognitive-activity component* has an applied character and is directly related to the training of future specialists. This block reflects the process of learning and includes both formal and non-formal and informal education: basic knowledge, project activities, cooperation with research centers and communities.

We conducted a survey aimed at establishing the experience of using different teaching methods in students. We interviewed students of natural sciences and mathematics. The questionnaire consisted of two types of questions: choose one or more answers, as well as questions with a score on the Likert scale. The questionnaire also provided the opportunity to add your own comments to the questions, in case there were no answers in these options.

The process of preparing future teachers of natural and mathematical disciplines for the application of STEM technologies in their professional activities takes place in the course of the sequential implementation of five stages, namely: initial, introductory, quasi-professional, professional-practical and resulting. Moreover, each of the defined stages has its own goal and objectives.

So, the purpose of the *initial stage* is to determine the initial state of readiness of future teachers of natural and mathematical disciplines to use STEM technologies.

The objectives of this phase include:

1) preparation for experimental work;
2) involving future teachers of natural and mathematical disciplines in experimental work;
3) determination of the initial state of readiness of future teachers of natural and mathematical disciplines to use STEM technologies.

The *introductory stage* of preparation is aimed at actualizing future teachers of natural and mathematical disciplines as the main providers of STEM education to schools and initiating their interest in the use of STEM technologies.

The main tasks of this stage are:

1) awareness by future teachers of the importance of their professional activity as a teacher of natural and mathematical disciplines for STEM education;
2) awareness of the complexity and multidimensionality of the professional activity of a teacher of

natural and mathematical disciplines in the context of STEM education;

3) initiation of the interest of future teachers of natural and mathematical disciplines in the application of STEM technologies in professional activities by preliminary acquaintance with the means of STEM education;

4) providing students with the opportunity to express their own experience and impressions received during their acquaintance with their future profession and STEM education;

5) actualization of future teachers of natural and mathematical disciplines as the main providers of STEM education in schools.

The *quasi-professional stage* of preparation should ensure the formation of knowledge, skills and value-motivational guidelines for future teachers of natural and mathematical disciplines, necessary for the application of STEM technologies in their future professional activities.

At this stage, the main tasks are:

1) theoretical training of future teachers of natural and mathematical disciplines for the use of STEM technologies in professional activities;

2) the formation of pedagogical and technological components of the readiness of future teachers of natural and mathematical disciplines and their content components;

3) the direction of the cognitive activity of future teachers of natural and mathematical disciplines to acquire a quasi-professional experience of using educational information in situations that imitate professional activities;

4) the formation of value orientations among future teachers of natural and mathematical disciplines, united around the conscious use of STEM technologies;

5) the formation of future teachers of natural and mathematical disciplines of a holistic understanding and vision of their future professional activities in the context of STEM education.

The *professional-practical stage* of preparation provides for testing students in the role of teachers of natural and mathematical disciplines and the correction of ineffective behaviors using STEM technologies.

The objectives of this stage are:

1) testing students in the role of teachers of natural and mathematical disciplines;

2) testing the pedagogical readiness of the future teacher of natural and mathematical disciplines;

3) testing the technological readiness of the future teacher of natural and mathematical disciplines;

4) the awareness of future teachers of natural and mathematical disciplines of the value of the knowledge, skills and quasi-professional experience acquired by them for further professional activity in the conditions of STEM education;

5) the awareness of future teachers of natural and mathematical disciplines of their own readiness to use STEM technologies in their professional activities.

The goal of the final stage is to determine the final state of readiness of future teachers of natural and mathematical disciplines to use STEM technologies in their professional activities.

The objectives of this stage are:

1) determination of the final state of readiness of future teachers of natural and mathematical disciplines for the use of STEM technologies in professional activities;

2) summing up the results of the experimental work and drawing conclusions regarding the effectiveness of the developed model of the system of future teachers of natural and mathematical disciplines for the use of STEM technologies in professional activities;

3) if it is necessary to adjust the developed model of the system of future teachers of natural and mathematical disciplines to the use of STEM technologies in professional activities.

The developed model takes into account a set of organizational and pedagogical conditions that ensure the effectiveness of the implementation of the system of training future teachers of natural and mathematical disciplines for the use of STEM technologies in professional activities, namely:

1) updating the content of professional training of future teachers of natural and mathematical disciplines to use STEM technologies;

2) implementation of STEM projects in robotics by future teachers of natural and mathematical disciplines;

3) ensuring during the training of future teachers of natural and mathematical disciplines their social interaction in a professional environment.

In terms of the organization of environmental research and analysis of empirical data, it is necessary to ensure the study of STEM disciplines by means that effectively help: conduct research, create models to describe systems, organize experimental activities, conduct statistical processing of empirical data. The theory and practice of research can be linked through the use of simulators and virtual laboratories (Osadchyi et al., 2020b).

As part of the creation of a distance course "Fundamentals of Robotic Systems" for undergraduates, we used the above provisions regarding the technological and pedagogical aspects of the course. To do this, the following elements were introduced into the course:

1. Short motivational videos about the achievements of modern technologies and robotics. The motivational component is crucial for the formation of the worldview of future professionals, which is the result of the formation of value-motivational system of personal development. Any activity, including professional, is the result of the action of "value" regulators, which determine the motives and behavior of the individual. One can use the following topics to form a valued attitude to technology:
   - awareness of the place and role of technology in human life;
   - effective use of technology (competent, rational, timely, effective;
   - safe use of technology (both for themselves and for others);
   - environmental consequences of the use of technology.

   The value-motivational component has different levels of formation, depending on the type of activity and its purpose. The initial level is characterized by activities aimed at forming an environment of communication and developing interest in the study of STEM disciplines. The next level is based on quasi-professional activity, the value of which is determined by the degree of conscious use of STEM technologies. The third level is characterized by awareness of the value of knowledge through the prism of scientific and technological picture of the world and readiness for such activities. The final level is the formed need and ability to transfer experience, knowledge, values in the process of communication.
2. The content of training is a decomposition of elementary topics of connection of robotic devices. Execution of such elementary task allows to carry out activization of cognitive activity on related subjects: physical properties and laws, designs and algorithms of programming, engineering of designs, etc. Each of the tasks has a clear practical significance. The purpose of such construction of the material is to form conceptual connections between theory and practice, to plan the study of fundamental disciplines, to create a field of interaction between the participants of the educational process. Due to the unavailability of robotic designers for the quarantine period, the Tinkercad environment was chosen to perform the work. A number of projects were created that simulated various robotic systems in a virtual environment.
3. Each completed task was available for discussion in the team through a system of links in the course. Thus, students could get acquainted with the work of classmates and make suggestions for improving the presented projects. Such social expertise proved to be effective enough to form a critical view of their own projects and to analyze and discuss the results of modeling robotic systems.

Thus formed STEM training course provides the implementation of the functioning of distance STEM education. Resource components of the distance STEM course for teaching undergraduates the basics of robotics – software, hardware, teaching and methodological support (Valko and Osadchyi, 2021) – were adapted to the distance educational process in order to form an educational environment for distance STEM learning.

4 CONCLUSIONS

As a result of the study, it was found that the transition to distance learning requires teachers and educational institutions to change approaches to teaching and building courses. Such changes must be justified not only at the technological but also at the pedagogical level. Based on the various models of distance learning, the article identified the features of distance learning STEM disciplines. The components of the system of teaching students to study STEM disciplines are determined: value-motivational, content-organizational, cognitive-activity for the implementation of project activities, reflexive-analytical. The distance learning model must take these components into account and ensure their integrity. The principles of preparing students for the study of STEM disciplines were taken into account in the organization of distance learning in STEM specialties. Pedagogical and technological aspects of distance learning construction are considered. Pedagogical aspects are the activation of cognitive processes and active involvement in the cognitive process. The technological aspect is a set of rules for organizing the elements of the distance course. The skills that should be formed as a result of such training are singled out.

Therefore increasing the efficiency of the distance educational process and solving the pedagogical aspect is possible through the correct technical organization and structure of the distance course.

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Use of Information and Communication Technologies in the Organization of Blended Learning of Future Vocational Education Professionals

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Keywords: ICT, Blended Learning, Online Learning, Vocational Education.

Abstract: The ability to use the means of modern communication at different stages of the educational process, combining technical means with the latest educational technologies, is now a prerequisite for modern education. The methodological features of the use of ICT in information retrieval, project development, evaluation and self-evaluation are highlighted. Options for the appropriate use of public computer programs and means of communication to support online and blended learning, optimize feedback between the subjects of the educational process, an innovative approach to complex tasks. Mastering the tool software should become a fundamental part of the methodological system of education at the University.

1 INTRODUCTION

Due to the introduction and dissemination of innovations in the field of education, an educational system of open, flexible, individualized, creative knowledge, continuous education of a person throughout his life is formed. This system should combine the following components: modern educational technologies, new methods and techniques of teaching and learning (pedagogical innovations) and new means of interaction in the educational process, i.e. information and communication technologies.

Conceptual principles of continuous professional training of future specialists in vocational education are based on the paradigm of personality-oriented education (Ball, 1997; Ziaziun, 1989); theory of professional pedagogical education (Horbatiuk et al., 2020; Lavrentieva et al., 2021); theory and methods of use of information and communication technologies (ICT) in the educational process of higher education (Osadcha and Osadchyi, 2014; Striuk and Semerikov, 2012; Zakharova, 2003) and others. The concepts of "quality of training" and "competence of a specialist" are although related, but they are not identical and reveal different aspects of the educational process. Thus, the quality of education and the competence of the specialist may be in the relation "condition-goal". The formation of a competent specialist is the result of quality implementation of all stages of the educational process.

The expansion of the Internet, the rapid increase and "rejuvenation" of the audience of users of global electronic resources leads to the spread of the use of Internet-oriented technologies in education, in particular in the training of bachelors of vocational education. On the other hand, the process of technologicalization of education is accompanied by the involvement of students in mastering the techniques of using the capabilities of computer technology.

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training of the future specialist can be divided into three areas (means of searching and exchanging information; electronic educational resources and instrumental art; technical software) which should have a comprehensive interaction on the personality of the future specialist. In the developed model of formation of professional and pedagogical competence of the future master of technological education, Yashchuk (Yashchuk, 2007) singled out pedagogical (design, interactive, positional, contextual, trainings) and information (networks, computer multimedia, Web-technologies, electronic textbooks) technologies.

Based on the existing psychological and pedagogical concepts of professional development of a specialist in the system of vocational education and taking into account their own considerations, we believe that the formation of his professional competence (as a set of key, general and specialized) occurs in four stages:

1) development of universal key competencies common to all disciplines in the context of future professional activity;
2) formation of general professional competence (reflects the modern understanding of the main tasks of professional activity of the specialist)according to professional standards on the basis of the key competence (show ways to solve them);
3) formation of specialized competence on the basis of developed general professional competence (in relation to the specifics of a particular professional activity);
4) development of specialized competencies.

The main task of the study is the use of information and communication technologies for the organization of blended learning (in distance or blended education), when the learning process can take place in various forms (online and offline), the purpose of which is to form the competence of the specialist. In addition, there are now significant opportunities in the implementation of educational activities at anytime, anywhere, with the condition of interaction between teacher and students by means of mobile learning, which is one of the subtypes of distance learning or e-learning (Gorbatyuk and Potapchuk, 2017; Vlasenko et al., 2020).

The *purpose* of the paper is to identify the versatile capabilities of using ICT in conditions of distance and blended training, which provides the basis for the implementation of all stages of educational projects. Formation of professional special competences of future bachelors of vocational education related to willingness to exercise and guide of design, modeling and manufacturing of clothing, is an expected result of the use of modern capabilities of ICT.

2 RESULTS

Research using project method by future bachelors of vocational education were used some methods: analysis, synthesis, modeling; pedagogical experiment.

The practical implementation of the competence approach in higher education brings to the fore the task of developing a methodological system for each discipline, which would correspond to the pedagogical model of forming the professional competence of a graduate of a higher education institution.

Based on the key competencies of the future vocational education specialist, we have developed criteria that will determine the effectiveness of our research: K 06. Skills in the use of information and communication technologies; K 07. Ability to learn and master modern knowledge; K 14. Ability to manage training / development projects; K 16. Ability to use modern information technologies and specialized software and integrate them into the educational environment; K 17. Ability to implement learning strategies based on specific criteria for assessing academic achievement (MON, 2019).

3 MATERIAL

In modern conditions, the future specialist must be able not only to use a computer, but also to set and solve professional practical problems with its help. He must have a sufficient level of mastery of technologies for access to local and global network information resources; to know the tendencies of development of modern computer technologies and possibilities of their using in further professional activity.

Basic skills of the organization of distance learning using ICT include that all participants in the educational process have the skills to use a personal computer, Internet skills, experience using office programs, etc. CAD technologies as automatic design systems are a necessary means of achieving a professional level in the execution and graphic design of projects of various kinds.

We believe that a certain pedagogical model of the formation of professional competence of a graduate of an educational institution should correspond to a special methodological support of academic disciplines, which will be aimed at forming the subject results of a particular educational program.

ICT and distance learning technologies have been long recognized as modern pedagogical technologies, the most used in the training of future professionals, as well as design, integrative-modular, modular rating, problem-based learning case technology, development cooperation technology, etc. (Sapozhnikov, 2016). The ability of the teacher to innovate is, first of all, the desire and ability to develop their interests and ideas, to seek their own non-traditional solutions to problems that arise, to perceive and creatively implement existing non-standard approaches in education.

The introduction of ICT in the education system has become a key element of the education reform of the world's leading countries. The concept "Internet-oriented pedagogical technology" Zhuk (Zhuk, 2017) interprets as a means of learning that contributes to the realization of the pedagogical idea.

Today the most successful form of organization of the educational process in higher education is blended learning. Blended and online learning under quarantine restrictions have become an integral part of educational practice (Polhun et al., 2021). Developing in this direction, domestic teachers have the opportunity to benefit from the experience of other countries, where online learning has been developing strongly since the early 2000s. Potential advantages of online education: student-oriented approach (the teacher does not control the learning process alone, but acts as a facilitator); joint interactive learning (priority of learning in small groups, receiving tasks for discussion in advance); metacognitive awareness (students' understanding and application of models and strategies for effective learning); increased flexibility (independent control of students of their pace and time); instant feedback (discussion to understand complex concepts, search and correct misconceptions about the subject of study); combined content (a combination of different ways of presenting multimedia content) (Smith and Brame, 2014). But the role of the teacher is still important, which create an interactive atmosphere of support and collaboration in which students can reap the benefits of online learning.

The use of mobile technologies provides an opportunity to expand educational tasks, in particular, the professional content and joint activities of teachers and students at different stages of learning disciplines, creating conditions for giving a mass character to individual learning. The combination of traditional forms of learning and mobile learning has features (Gorbatyuk and Potapchuk, 2017):

1) students use mobile devices for learning in cases where they can not use a computer;
2) the use of mobile technology allows students to use free time to study;
3) the opportunity to carry out joint online work on group projects, equal access of all participants to training;
4) the ability to perform individual time-discrete learning activities of students;
5) organization of webinars – a way to organize meetings online, the format of seminars, trainings and other events via the Internet, for their organization using video conferencing technologies using services such as Viber, Skype, WatsAp and others.

Objective social factors contributed to the rapid development of e-learning and blended learning in all educational institutions in Ukraine. As you can see (figure 1), the number of developed electronic training courses for bachelors in vocational education in specialty 015, locally presented on the Moodle (https://moodle.kdpu.edu.ua/course/index.php?categoryid=5), has grown significantly.

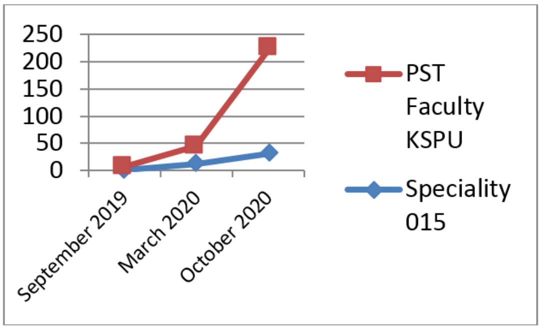

Figure 1: Number of developed e-learning courses on the platform Moodle KSPU.

For example, Moodle is the main LMS at Kryvyi Rih State Pedagogical University (KSPU) (Mintii, 2020). But distance and blended learning on e-learning platforms (Moodle, Google Classroom, local educational sites) do not in themselves provide student activity. Lack of personal contacts reduces the activity of students in performing tasks. Therefore, we are convinced that innovative media are particular value during distance learning, as they provide opportunities:

- diversification of forms of presentation and acquisition of educational material;
- communication, cooperation in groups;
- mutual evaluation and self-evaluation and feedback.

The main task of the teacher is to select information and methodological material that corresponds to the program and the level of students and directs them to use the appropriate resources. In designing blended learning, special attention should be paid to the coverage and accessibility of e-courses (which includes materials, tasks, ability to take, discuss, etc.), providing students with a sense of community (rather than isolation and anxiety), student-centered learning, blended content within electronic course.

Consider the possibilities of modern ICT according to the main stages of development of educational projects (because it is the project approach we consider appropriate for the construction of professional training courses).

In our opinion, the special competence of the bachelor of vocational education, which is associated with the use of ICT in professional activity, is the ability to create materials for online learning, the ability to ensure the interaction of participants in the design process, ICT skills in organizing almost all stages of design.

At the stage of organization and preparation of the project tasks there is an active exchange of views, which requires communication of student groups with each other and with the lecturer. The simplest solution for this can be a forum or group chat. But we consider electronic boards in which it is possible to accumulate information in a visual form and to transfer the best means.

Electronic boards that are indispensable in addition to online learning platforms (“Padlet” electronic board, “Miro” online board, “SMART” Board interactive, “Blackboard” mobile application). E-boards can be built into a ready-made training course to ask questions in a group, download files (doc, pdf, jpg, png), and disseminate research results (individual and group). There can be downloaded module, treasury of resources or tools needed to work on the course, additional tasks with the ability to obtain additional points (Litvin, 2020).

We consider that interactive whiteboard SMART Board (developed by SMART Technologies (Canada) can be used to implement the concept of blended learning as a basic tool. The interactive whiteboard is an ideal solution for classroom work of all age groups, including students. The interactive whiteboard uses the latest developments in Touch technologies with surface type recognition. The capabilities of SMART Notebook software allow you to create quickly the highest quality and visually enjoyable lesson, without much effort and specialized knowledge. The teacher has the opportunity using a gallery of images and multimedia files (which is already partially embedded in the software), interactive tasks, page templates and themes (SMART, 2020).

Most often, the interactive whiteboard in the classroom is used as a means of frontal work with students and involves careful preparation and development of the necessary set of slides with learning materials and tasks. At the stage of designing slides in the SMART Notebook program, it is important to anticipate the methods of working with the interactive whiteboard at different stages of the lesson.

Among the methods of working with an interactive whiteboard, the most suitable for activating the cognitive activity of students in lectures may be: the reception “Write by hand” (with the help of the “Magic Pen” tool on the slides, the teacher makes notes, making graphic comments, and students perform the same task on the interactive whiteboard in turn insert missing symbols and words, sign, underline, circle, establish a connection); the reception “Drag and Drop” (allows you to move the object on the board from one place to another, to match objects, group, sort, restore the correct sequence, arrange the elements in ascending or descending order, to construct objects from a set of details) (Ivanova, 2012; Kiurshunova, 2017). Such work is successfully used in mastering the thesaurus of professional disciplines, such as designing and modeling clothes. It is also advisable to use these techniques in the study of foreign languages for professional purposes.

The Blackboard mobile application is quite affordable. It presents the teacher and students with all the possibilities of online learning in one place: view course materials, complete tasks and tests, evaluate tasks, lead discussions and collaborate in the Blackboard Collaborate. The site of the platform provides quite detailed instructions that help users quickly learn to work in the apps.

The stage of design and technologically sound product development is marked by a close correlation with the professional activity of a design engineer and the specifics of graphic activity. The specificity of graphic activity is due to the variety of ways of forming graphic information, its forms, functions, the nature of graphic problems and the conditions for their solution.

The software package is the main means of solving practical problems for future teachers of any specialty, providing opportunities for technical processing of text and visual material. Usually, the Word text editor allows you to prepare handouts and didactic material; Access databases and PowerPoint electronic presentations are used to organize and present information at the appropriate scientific and methodological level, rationally and efficiently using learning time.

Speaking about future bachelors of vocational education, we pay special attention to the need to form students' constructive competence as an important component of them professional competence. One of the characteristics of design thinking is the ability to synthesize knowledge and skills acquired in the study of many special disciplines. Therefore, it is effective to train a specialist based on the principle of interdisciplinary integration, which is implemented through ICT, special engineering and psychological and pedagogical disciplines. The double professionalism of the engineer-teacher, according to (Tarkhan, 2005), allows them to work in all branches of production, where engineering activities take place not only in the system "man-machinery", but also in the system "man-man".

Object design can be successful when it is based on general intellectual and specific skills to find a basis for the integration of different subject areas, evaluate the results of their own activities, and model the transformation process. The future engineer-teacher must: conduct design analysis and synthesis of the object of transformation; build proportionally dependent relationships; transfer knowledge from one subject area to another in order to apply them to describe the system of transformation activities; determine the level of readiness of the object for the transformation process; make constructive and technologically sound decisions and implement them in practice; choose rational ways of transforming activity; plan, forecast and evaluate the effectiveness of transformation activities; to create spatial models of technological processes.

One of the professional tasks of the future teacher of vocational education is to design garments in a complex. In particular, when performing course work on the design of garments, we offered students a project development algorithm similar to the work of a clothing designer on a collection. The stages of project development were: search for current issues in the garment industry; analysis of search sources; generalization of information and formulation of the concept of the product or collection; sketch project of a perspective collection; development of the design and manufacturing technology of the experimental sample.

During the project at the stage of choosing the theme and the main design concept we use brainstorming. Initially, students were asked to create mind maps to reflect their own ideas. The next step was to create a group mind map, where all the ideas were collected and in some way completed in separate sectors. As a result, several or one idea was selected to serve the solution. Thus, the interim and final results of the "brainstorming" were recorded and streamlined, so that the chosen decision was justified and presented by the elected representative of the expert group.

Students created mind maps using Mind Mapping (figure 2) in the Miro environment. Then, at the stage of developing sketches, design and technological sequence of manufacturing the product, the teacher can invite students to form groups in different "expert profiles". Each group of experts (designers, constructors, technologists, seamstresses, etc.) reviews the project, presenting the results in the form of grouped key concepts on the board.

Figure 2: Mind map of brainstorming at the stage of project concept development.

In the practice of designing garments at the stage of design of the idea of the collection has become commonplace the use of moodboards (inspiration boards). Moodboard is a very convenient way to visualize an idea. It can be composed of images of natural objects (primary sources of inspiration) and works of art, design, etc. Online boards are also used to create a moodboard in the process of determining the shapes and decor of the future garment (figure 3).

In the conditions of fast-changing industrial technologies, product design it is difficult to train future specialists for work in a professional education. Disciplines such as "Systems and methods of clothing design", "CAD in the garment industry", "Design by computer graphics" play an important role in the

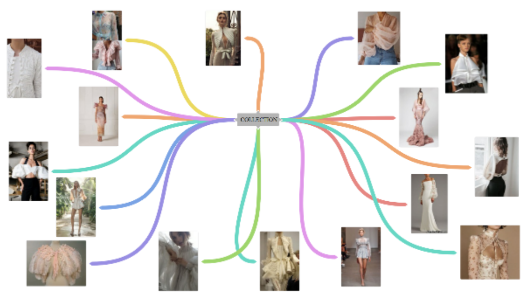

Figure 3: An example of creating a moodboard in the design process of garments.

development of professional thinking of a new type of engineer-teacher with high creative potential, engineering thinking to solve technical problems. At present, the garment industry cannot do without computer information technology. Computer-aided design systems increase the competitiveness of modern enterprises, which makes it possible to respond quickly to changing market needs. Future teachers of vocational education need to be prepared for the introduction of new technologies and develop their graphic skills and abilities in the process of designing clothes.

Designing clothes is one of the most difficult stages in creating a garment. The development of drawings of parts and the manufacture of patterns for cutting – a complex process that is facilitated by the use of CAD – automated design and calculation systems. In modern industry, several dozen computer-aided design systems are used for light industry. CAD for any industry has an identical structure and consists of approximately 10 subsystems: I/O, generation and input of information; computational process management; information retrieval subsystem; designing the basic foundations of the structure; design of new clothing models (constructive modeling); design of basic patterns and patterns of derived parts; designing sets of patterns; design of clothes of industrial production and by individual orders of the population; quality management; design of waste standards.

Of the large number of foreign companies developing software for the garment industry, it is worth noting Assyst, Zeuze (Germany); ToreyIndustries (Japan); CDIMicrodynamics, GDT, Gameo (USA); LectraSystems, Pantotus (France); InvestronicaSistems (Spain); AMFReese (UK); GIGMobil (Belgium). Julivi (SAPRLEGPROM, Ukraine), Gracia (Infocom, Kharkiv), AvtoKroy (NPP Lakshmy, Belarus) and others use sewing CAD at domestic enterprises. Special programs for clothing design are quite expensive and it is not always cost-effective for pedagogical university to purchase and maintain them.

However, there are open access programs that are available for use by educational institutions and individual users in particular. Thus, the successful use of the vector graphic computer program nanoCAD 5.1 in the training of specialists in technological education in the study of design and modeling of clothing contributed to the formation of general computer literacy in the processing of graphic objects (Kucher, 2017; Boichuk et al., 2019).

New opportunities appeared with the advent of a free program of graphic design of clothing "Valentina", which is designed to build the basic foundations of garments for any design system (Bukhteev, 2017). The program is suitable for use in the design of garments of any range (from coats to underwear). The main condition for its use, we consider the basic level of knowledge of the user of a particular technique (system) of clothing design.

For example, at the stage of developing the design of the future garment for third and fourth year students who have already mastered the Unified Method of Clothing Design (UMCD) when studying the course of clothing design, it is not difficult to work in the proposed program (figure 4). Construction of points and segments is carried out with the help of various tools and commands, most of which coincide with other graphics programs.

But there are some features of the program "Valentina". Basic bases can be built on standard (standard) measurements, or on individual. The advantages of the program are the ability to build several items of clothing on one screen; change the already constructed structure according to the newly introduced measurements; to form a pattern with assumptions for technological processing and to plan the layout of parts on the fabric (figure 5). In our opinion, the presence of specific tools in the program is positive: "display the object on the axis", "display the object on the line", "darts", which facilitate the manipulation of objects, bringing them closer to the familiar clothing designer operations.

The final stage in the project implementation involves reflection, self- and mutual evaluation.

Students' implementation of the project does not require the direct guidance of the teacher, but is accompanied by his observation, consultation, monitoring and evaluation. Individual intermediate results of the project are recorded in an electronic journal, and both the teacher and the student can track them at any time. Since in the process of implementing the educational project there are individual and group forms of work, the teacher must methodically competently build assessment activities.

Feedback in the design process can occur continuously and with a certain frequency (input, intermediate, final control). During and at the end of each online lesson the short surveys that are used with the Mentimeter resource give the teacher a quick response from the participants. Periodic control activities are carried out in the form of testing as part of an e-learning course in the Moodle system. Final testing made it possible to obtain information about the level of assimilation of certain educational material.

We propose to evaluate the educational activity of students who work in small groups on the basis of the technology of collective thinking. After receiving the task, students develop their own methods of determining certain indicators (for example, establishing the

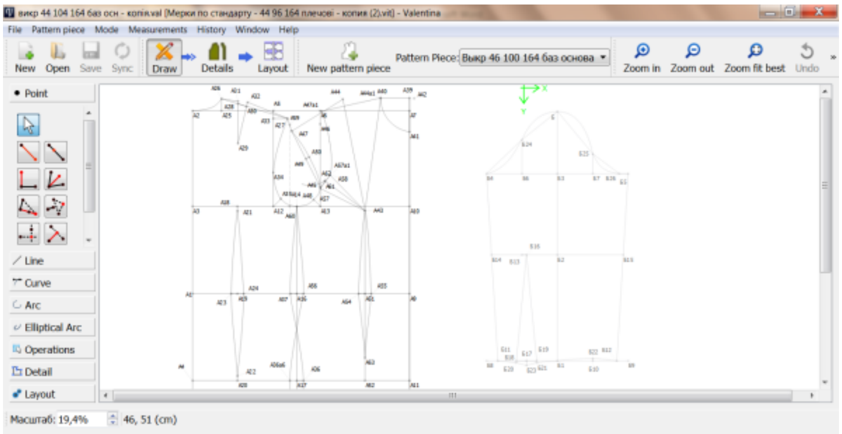

Figure 4: An example of constructing of the dress basis (with sleeves) in the program "Valentina".

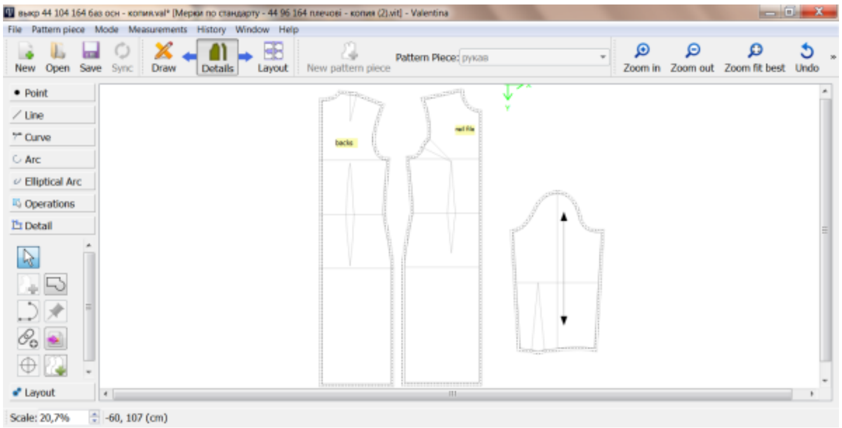

Figure 5: Preparation of patterns for printing in the program "Valentina".

basic principle of building harmony in the pattern). Then the task is performed in three stages: individual work, discussion in a micro group, presentation of a collective decision.

In the course of project implementation, we have set a goal to demonstrate the effectiveness of the organization of blended learning using various ICTs in accordance with the tasks of each stage of the design, compared with traditional learning.

Students' questionnaires showed that they mark the value of its own ability to create materials for e-learning.

Students noted that project development using ICT was more systematic and understandable on demands. Instead, students who performed projects in distance learning by the usual algorithm (project stages are performed by finding information on the Internet, creating a text file and presentation file) complained of difficulties in the stages of analysis, synthesis and presentation of information, design and modeling.

The dynamics of the development of professional qualities of future professionals of professional education gives us reason to conclude on the effectiveness of using ICT at all stages of educational design.

4 CONCLUSIONS

The combination of e-learning courses with online learning and information exchange tools increases the number of students involved in active cognitive activities. The responsibility for the learning process and the feeling of being in the community during distance learning is growing. At the same time, it should be noted the student-oriented nature of this method of learning, because the teacher receives instant feedback and can make changes in the organization and content of the educational process. The ability to provide combined content in different ways significantly enriches the educational and methodological support of the course.

Thus, the use of information and communication technologies is an integral part of the modern educational process. The prospect of further exploration on the topic is related to the development of a blended learning system based on an interdisciplinary approach.

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Virtualization Technologies in the Training Future IT Specialists to the Subject "IP Telephony"

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Abstract: The application of virtualization technologies to train future IT specialists in IP telephony has been considered in the article. Requirements for students' professional training in the field of IP telephony have been defined. The components of the network training laboratory for training IP telephony have been determined. Modern approaches to the application of virtualization technologies have been analyzed. Features of using virtualization technologies for learning IP telephony have been determined. The analysis of modern virtualization technologies has showed the prospects of using native virtualization as a basis for creating a virtual training laboratory using VirtualBox software. The conducted pedagogical experiment has confirmed the effectiveness of using the developed virtual laboratory and repository of virtual hosts for training IP telephony to future IT specialists. Virtual machines increase student mobility, they can be exported and moved to another computer, and there the virtual machine can be started immediately. This is a significant advantage of virtualization during the SARS-CoV-2 pandemic, when students have to study remotely. Each student can have his own virtual laboratory.

1 INTRODUCTION

Training of future IT specialists is not possible without the application of modern learning technologies, including information. The general trend in the world is to equip higher education institutions with modern software and hardware. Today there is a rapid development of hardware and software, the emergence of new and improvement of old hardware platforms (Pavlenko and Pavlenko, 2021). It causes a constant lag of the educational process from today's requirements, and complicates the adaptation of higher education institutions and the growing demands of society to the quality of training in the field of information technology.

This problem becomes more noticeable in the training of future IT specialists in the discipline of "IP telephony in computer networks". To prepare them, it is necessary to ensure the solution of the following issues:

- mastering the knowledge and skills related to the various operating systems installing, functioning and exploitation, taking into account network interaction, both in local and global networks;
- mastering the knowledge and skills related to the installation, debugging, operation and exploitation of IP telephony software, taking into account network interaction, both in local and global networks.

One of the ways to solve a certain problem is the introduction of virtualization technology in the educational process.

The analysis of approaches to the application of virtualization for training future IT professionals shows the lack of a single concept of its implementation and application. The design and implementation of virtualization technologies requires the solution of many organizational, methodological and technical problems.

The development and application of virtualization technologies in various fields of computer science are reflected in (Balyk et al., 2019; Holovnia, 2020; Khomenko et al., 2020; Lunsford, 2009; Osad-

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chyi et al., 2020; Ray and Srivastava, 2020; Stefanek, 2017; Yan, 2011; Yuan and Cross, 2014; Yuan et al., 2012).

The problem of using virtualization in the teaching of information technology was considered in (Chamberlin et al., 2017; Barrionuevo et al., 2018; Khomenko et al., 2020; Korotun et al., 2020; Markova et al., 2019; Merzlykin et al., 2017; Segeč et al., 2019; Soler, 2011; Yuan et al., 2011, 2013).

The problem of using virtualization in the training IP telephony to future IT-specialists was considered in (Abubakr et al., 2019; Kaul and Jain, 2020; Moravcik and Kontsek, 2019; Rendon Schneir and Plückebaum, 2010; Setiawan et al., 2017).

The *aim* of the article is to analyze the possibilities of using existing virtualization technologies to train future IT specialists in IP telephony in computer networks.

2 REASONING FOR CHOOSING A VIRTUALIZATION SYSTEM FOR LEARNING IP TELEPHONY

Training of future IT specialists in accordance with the state standard of higher education involves the formation of a number of professional competencies: the ability to use operating and intelligent systems in solving practical problems, taking into account the protection of information in computer systems and networks; ability to use programming languages and software engineering in solving problems and tasks of social and professional nature; ability to analyze, debug, use and develop human-machine interaction based on computer architecture and organization.

They are formed during the study of a number of professional-oriented disciplines, one of which is “IP telephony in computer networks”.

In accordance with the purpose of the study, we will consider virtualization technologies and identify prospects for their application to train future IT professionals in IP telephony in computer networks.

The study of “IP telephony in computer networks” uses two Asterisk servers based on Debian or Ubuntu Linux and at least two client personal computers with Windows operating systems and IP telephony software installed as a network training laboratory. This hardware and software are necessary to model the network interaction of IP telephony clients and servers using SIP, IAX2, H.323 protocols. One of the areas of a network laboratory development and implementation for the study of IP telephony is the application of virtualization.

The concept of virtualization appeared in the 1970s. It was understood as the transfer of physical resources of a computer into a virtual one with the help of specialized software, abstract layers allow creating several virtual machines on one physical machine, each virtual machine being able to work with its operating system (Drews, 2006).

Virtualization, as a concept, is used for two technologies that are fundamentally different: resource virtualization and platform virtualization. Resource virtualization, in contrast to platform virtualization, has a broader meaning and combines a large number of different approaches aimed at improving the usability of users with information systems in general. In our study, we will build on the concept of platform virtualization, as related technologies are evolving and are effective in achieving the goals of training future IT professionals.

Platform virtualization is understood as the creation of software systems based on existing hardware and software complexes. A system that provides hardware resources and software is called a host, and the systems it simulates are called guest systems. There are several types of virtualization platforms, each of which has its own approach to the concept of “virtualization”. They are mainly determined by how full the hardware simulation (Barr et al., 2010).

We will consider virtualization with full emulation. This approach completely virtualizes all the hardware while keeping the guest operating system unchanged (Han and Jin, 2011). This allows you to simulate different hardware architectures. For example, you can run virtual machines with guest systems for x86 processors on platforms with a different architecture. Examples of software for complete simulation are: Bochs, Pearpc and QEMU.

The main disadvantage of this approach is that the simulated hardware significantly slows down the performance of the guest system, which makes interaction with it very inconvenient. Therefore, such products should not be used as a basis for developing a virtual training laboratory to study “IP telephony in computer networks” discipline.

Let’s consider paravirtualization as a basis for the development of a virtual training laboratory for the study of the “IP telephony in computer networks” discipline. While using paravirtualization, the hardware is not simulated, a special software interface (API) is used to interact with the guest operating system at the level of RAM pages.

This approach requires modification of the guest system code. A significant number of hardware and software developers have doubts about the prospects of this approach to virtualization (Babu et al., 2014), because today all decisions of hardware manufacturers regarding virtualization are aimed at systems with native virtualization. In addition, it should be noted the difficulty of deploying new instances of virtual machines for users. Therefore, the use of paravirtualization software in learning IP telephony in computer networks is impractical. Examples of paravirtualization are Xen, L4, TRANGO, WindRiver and XtratuMhypervisors.

We will consider partial (native) virtualization in the context of our study. In this case, only the required amount of hardware to run an isolated virtual machine is simulated (Li, 2010). This approach allows you to run guest operating systems designed only for the same architecture as the host.

In this way, multiple samples of guest systems can be run simultaneously, allowing you to simulate a computer network with IP telephony servers and clients on a single personal computer. This type of virtualization can significantly increase the speed of guest systems compared to full emulation and it is widely used today.

Beside this, the distribution of already established guest systems among users is quite simple and possible only on the basis of copying files. Disadvantages of this type of virtualization include the dependence of virtual machines on the architecture of the hardware platform, but for the "IP telephony in computer networks" discipline we use operating systems and software for x86 architecture. Examples of products for native virtualization: VMware Workstation, Virtualbox, Parallels Workstation and others, including server solutions (VMware Server, Microsoft Virtual Server, VMware ESX Server, VirtualIron and Microsoft Hyper V).

We will consider the virtualization of the operating system level and identify opportunities for its use to train future IT professionals in IP telephony in computer networks. The guest system, in this case, shares the use of one kernel of the host operating system with other guest systems (Yan, 2011). The virtual machine provides an environment for applications that run in isolation. This type of virtualization is used in the organization of virtual hosting systems, when you need to support multiple virtual client servers within one instance of the kernel.

This technology allows you to isolate each virtual system and deprive them of the ability to influence each other. Examples of operating system layer virtualization include: iCoreVirtualAccounts, Linux-VServer, LXC, OpenVZ, ParallelsVirtuozzoContainers, FreeBSDJail and sysjail.

We will consider virtualization of the application level. This type of virtualization involves the creation of separate containers for software isolation. The container includes all the necessary elements for the correct operation of the software: registry files, configuration files, user and system objects. As a result, the user receives an application that does not require installation on a similar platform.

Transferring the software to another computer will create a virtual environment for it, and the virtualization program resolves conflicts between the software and the operating system and other applications. Examples of such an approach are: Thinstall, Altiris, Trigence, Microsoft ApplicationVirtualization (App-V). Using application-level virtualization to train IP telephony to future IT professionals is impractical, due to the need to create a computer network model with separate servers and workstations rather than software.

So, we can affirm that one of the best solutions for the introduction of virtualization in the methodology of teaching IP telephony discipline in the computer networks will be the technology of native virtualization. This can be explained with the ability to use virtual machines in independent and classroom work of students, easy export of ready-made solutions and the ability to create a complex network infrastructure among downloaded virtual machines.

Let's consider the problem of choosing the specific software for native virtualization in order to use it to teach IP telephony in more detail. Let's analyze the possibility of using one of the three popular solutions for virtualization in the workplace: VMware Workstation, Parallels Workstation and VirtualBox.

VMware company is one of the best known in the high technology industry. It develops effective software in the field of virtualization. Their implementation of server software is widely used in virtual data centers and personal computers in business and industry.

VMware has two types of desktop software: VMware Workstation and VMwarePlayer. Every virtual client supports and works with virtual machines flawlessly. But the Workstation option has more features, namely: support for two monitors, integration of the Unity interface, and most importantly the ability to create virtual machines. The Player version only allows you to run and execute previously created virtual machines.

Teaching IP telephony in computer networks involves students creating their own virtual machines, so VMwarePlayer software cannot be used due to the existing restrictions on creating new virtual machines.

VMware Workstation functionality allows you to use it on computers running Windows and Linux operating systems. The wizard for installing and debugging new virtual machines is simple and intuitive, and the default settings for specific operating systems are selected quite well. This allows students not to spend a lot of study time mastering software management skills.

Unity virtual interface integration allows you to include virtual machine elements directly into the host operating system interface. That is, icons and windows from a Windows virtual machine will work with icons and windows from the Ubuntu operating system. However, the use of Unity leads to a significant slowdown of virtual machines and complicates their use.

Parallels company is developing a software product for PC virtualization – Parallels Workstation. It solves the main task of virtualization – the simultaneous launch of multiple operating systems on a single computer running Windows or Linux. This product uses features designed for professionals in the field of local and online applications, software testing professionals and web designers. It can also be widely used for educational purposes.

During Parallels Workstation development the requirements for the product by IT specialists were considered. This software can work with more than 25 major operating systems – both 32-bit and 64-bit. High performance of Parallels Workstation is compatible with Intel VT-x2 virtualization technology and the use of a hypervisor.

However, owing to Controlled Native Execution (CNE) technology, Parallels Workstation allows you to run guest operating systems on older computers whose processors do not have hardware support for virtualization. Parallels Workstation's professional user interface offers many options for creating and configuring virtual machines, but an untrained professional will not be able to quickly create and install a virtual machine, making it difficult to use Parallels Workstation to teach IP telephony in computer networks.

VirtualBox is open source software, i.e. free of charge. Individual commercial functional elements are downloaded in the form of plug-ins. VirtualBox combines features of solutions for both servers and workstations. The first includes technologies of "balloon" dynamic redistribution and reduplication of RAM in a virtual machine on 64-bit hosts, iSCSI support, GUI-free mode and an efficient method of remote access to virtual machines through a shared RDP-server (VRDP, VirtualBox Remote Display Protocol). The second is high-quality support for USB equipment, including USB 2.0, as well as 2D and 3D acceleration in virtual machines due to the resources of the host graphics adapter.

VirtualBox can provide virtualization in a purely software mode or by using hardware support in modern processors. It uses disassembly of guest OS code and a number of other techniques, combining them.

While creating new virtual machines, the developers of VirtualBox managed to protect their users from possible problems and the need to understand the technical details. In most cases, it is sufficient to agree with the default settings, adjusting only the necessary and obvious of them, say, the amount of RAM.

In this case, the program will to some extent control the correctness of the selected parameters and, if necessary, make corrections or issue appropriate warnings. It is no coincidence that all the most subtle settings and actions can be performed exclusively from the command line, which, of course, requires the user to have some understanding of what is happening. These features are very convenient to use while creating and debugging virtual machines when learning IP telephony in computer networks.

As one can see from table 1 VirtualBox software supports multiple operating systems, allows you to connect up to 36 network adapters to a virtual machine and is distributed free of charge. All this points to the benefits of using VirtualBox as the main virtualization tool in the development of a network lab for training future IT professionals in IP telephony in computer networks.

3 REPOSITORY OF VIRTUAL MACHINES FOR TEACHING IP TELEPHONY

The content of the discipline "IP telephony in computer networks" involves a series of laboratory work:

1. Installing Asterisk and Free PBX.
2. Basic configuration of the IP telephony server.
3. Configure Asterisk to work with the SIP protocol.
4. Configure the Asterisk dial plan.
5. Calls management in Asterisk.
6. Voice services and menus in Asterisk.
7. Integration of Asterisk into the organization corporate network.

Two servers and several clients are required to perform laboratory work. Virtual hosts in the VirtualBox environment are created as servers. One core, 512 MB of RAM and 10 Gb on the virtual HDD are allocated for the Virtual Server. The client virtual

Table 1: Features of VMware Workstation, Parallels Workstation and Virtualbox.

Feature	VMware Workstation	Parallels Workstation	VirtualBox
Supported host operational systems	Windows, Linux, Mac OS X	Windows, Linux, MacOS X	Windows, Windows Server, Linux, Mac OS X, Solaris, OpenSolaris, FreeBSD
Guest operational systems	DOS, Windows, Linux, FreeBSD, Solaris	DOS, Windows, Linux, OS/2	DOS, Windows, Windows Server, Linux, OpenBSD, FreeBSD, OS/2, Solaris, OpenSolaris, others
Network adapters	before 4	before 5	before 36
Virtual disk controllers	IDE or SCSI	IDE (before 4)	IDE or SATA (before 32 disks) or SCSI
USB support	Yes	Yes	Yes
3D acceleration	Limited	No	Yes (OpenGL)
Remote access to the virtual machine	Limited	No	Built-in RDP server
Remote USB support	No	No	Yes
Shared folders	Yes	Yes	Yes
Open software	No	No	Yes
License cost	Workstation for Windows/Linux approximately $199	Workstation for Windows/Linux - $49.99	Free of charge

hosts configuration has 1 Gb of RAM and Windows 7 Home and LinuxMint 18 operating systems.

The server virtual hosts have the Ubuntu 18.04 and AsteriskFreePBX 15 operating systems installed.

Client virtual hosts have software for IP telephony using the SIP protocol – LinphoneDesktop 4 (https://www.linphone.org). This program is open and free. It works in Windows, Linux and MacOS operating systems.

Two IP telephony servers are required to simulate the interaction of server hosts on the Internet. Client hosts are used to test IP telephony features on users' devices (figure 1).

A set of virtual machines for application in VirtualBox has been prepared for each laboratory work. The developed virtual machines are placed on the internal server of Berdyansk State Pedagogical University. Students can download the required images of virtual machines to perform lab work at any time.

4 THE RESULTS OF THE EXPERIMENTAL RESEARCH OF VIRTUALIZATION TECHNOLOGIES INTRODUCTION IN TRAINING OF IP TELEPHONY

The introduction of virtualization technologies in the training of future IT specialists involves conducting experimental research. The purpose of the pedagogical experiment is to test the research hypothesis: the use of virtualization technologies to teach IP telephony to future IT professionals will help increase the level of knowledge acquisition and skills in the field of IP telephony and computer networks.

The offered methodological approach to the application of virtualization technologies for training IP telephony of future IT-specialists should provide the solution of the following tasks:

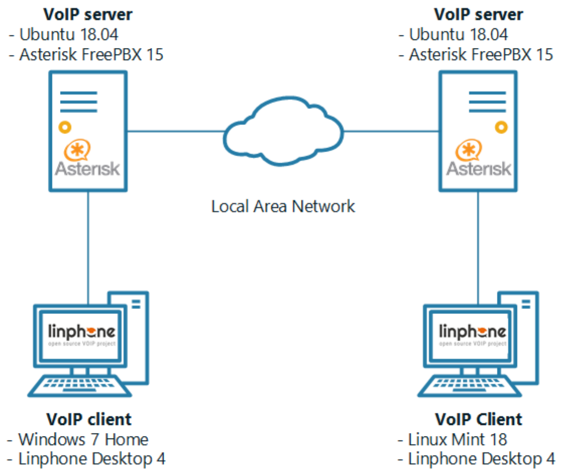

Figure 1: Virtual laboratory of IP telephony.

- software application for virtualization of servers and clients of IP telephony;
- systematic solution of debugging software problems and IP telephony protocols with the use of native virtualization;
- training time increasing to work with a network laboratory for the study of IP telephony.

Students of Berdyansk State Pedagogical University studying in the specialties 015 Professional Education (Computer Technologies) and 015 Professional Education (Digital Technologies) were involved in the experiment. The plan of the experiment provided for the creation of control and experimental groups. The experimental group consisted of 35 students and the control group of 39 students accordingly. Selection for control and experimental groups was carried out immediately before the study of “IP telephony in computer networks” discipline.

Classes in the control group were conducted using a hardware network laboratory. The method of conducting classes in such a laboratory provided for the organization of students’ access to the equipment according to the schedule.

The organization of the educational process in the experimental group involved the application of virtualization technologies using the VirtualBox software and the developed repository of virtual machines. Virtual machines were organized according to the educational tasks of the discipline and were configured to perform specific practical tasks for setting up network software for IP telephony.

The success of the pedagogical experiment was insured by the use of such research methods that guarantee a reliable result. The following methods of pedagogical research were chosen: pedagogical observation at all stages of the experiment, tests, analysis of laboratory work, analysis of test results in the experimental and control groups.

The experiment studied the dynamics of the knowledge acquisition level and skills development in the field of IP telephony technologies and computer networks. The experimental technique involved the use of virtualization technologies at all stages of learning:

- while studying new material, as a system for demonstrating the features of setting up technologies and protocols of IP telephony;
- in consolidating the studied material, as a mean of developing skills in the field of IP telephony;
- in independent work, as an environment for the implementation of a professionally-oriented project to configure IP telephony servers in the corporate network of the enterprise.

Two tests were conducted to test the effectiveness of the virtualization technology implementation. The first test was conducted at the beginning of the study of the discipline. The purpose of this test was to determine the readiness of students of control and experimental groups to study IP telephony and covered the issues of installation, configuration and administration of server operating systems and networks. The test consisted of fourteen basic level tasks and three advanced tasks.

The second test was conducted at the end of the study of “IP telephony in computer networks” discipline. It consisted of ten basic tasks and five advanced tasks.

A comparison of students’ knowledge acquisition level and skills development in the field of network technology and administration of server operating systems at the beginning of learning “IP telephony in computer networks” discipline revealed similarities in the levels of knowledge acquisition and skills of students in control and experimental groups.

A comparison of the results obtained after studying the discipline “IP telephony in computer networks” revealed differences between the levels of knowledge acquisition and skills formation in the control and experimental groups.

Table 2 shows the results of control works at the beginning and at the end of the experiment in the control and experimental groups.

Comparative analysis of tests results allows us to conclude about the positive dynamics of the knowledge acquisition level and skills in the field of IP telephony in both groups. In the experimental group the dynamics is more pronounced: a 14% increase in the share of students who coped with the task from 75 to 90% of the total (5% in the control group), a 19% de-

Table 2: The results of tests hold at the begging and at the end of the experiment.

	Before the experiment		**After the experiment**	
	Control group	**Experimental group**	**Control group**	**Experimental group**
Whole results of the test				
Managed with the test (%): including	90	94	90	94
• more than 90% from the whole work volume	5	9	10	14
• from 75 to 90% from the whole work volume	13	20	13	34
• from 50 to 75% from the whole work volume	62	65	67	46
• less than 50% from the whole work volume	20	6	10	6
Tasks of advanced level				
A part of students that have done:				
• more than 50% of the tasks of advanced level	5	14	5	54
• less than 50% of the tasks of advanced level	13	17	26	29
• those, who haven't reached the tasks of advanced level	82	79	69	17

crease in the share of students who coped with tasks from 50 to 75% of the total number of tasks (in the control group increased by 5%) (figure 2).

The share of students in the experimental group who coped with more than 50% of advanced tasks increased by 40% (in the control group the indicator hasn't changed). Statistical parameters of the experimental results are shown in table 3.

Analysis of the data in table 3 allows us to say about the positive dynamics in both groups, but in the experimental group the dynamics is more pronounced: the average score for the control work increased by 1.57 (in the control group by 0.85). In the Experimental Group, the median sample increased by 2 points. In the control group, the median increased by only 1 point.

Let's test the hypothesis of a normal sample distribution. We use Pearson's criterion for this. We formulate working hypotheses:

- H_0 – the empirical distribution is a subject to the normal distribution law,
- H_1 – the empirical distribution is a subject to another distribution law.

The results of the hypothesis test are shown in table 4.

Since it was found that all distributions obey the normal law, Student's criterion was chosen for further comparison of the samples (table 5). This will help to determine whether the level of knowledge acquisition and skills development in the field of IP telephony differ in the control and experimental groups. For this purpose working hypotheses were formulated:

- H_0 – levels of knowledge acquisition and skills development in the field of IP telephony of the two groups do not differ.
- H_1 – levels of knowledge acquisition and skills in the field of IP telephony in the two groups are different.

The obtained results indicate that at the level of significance $\alpha = 0.05$ the levels of knowledge acquisition and skills formation in the control and experimental group before the experiment coincide and differ after the experiment.

So, the results of the pedagogical experiment indicate that the research hypothesis has been confirmed, namely, the use of virtualization technologies to teach IP telephony to future IT specialists helps to increase the level of knowledge acquisition and skills in the field of IP telephony and computer networks.

5 CONCLUSIONS

Virtualization technologies were created primarily for the software applications development and testing.

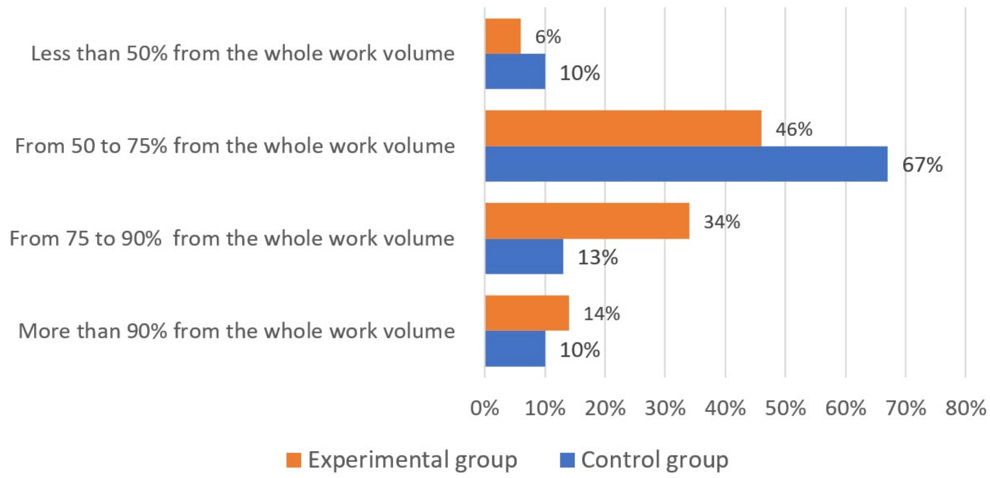

Figure 2: The results of test hold at the end of the experiment.

Table 3: Statistical parameters of knowledge acquisition levels and skills formation in IP telephony in the control and experimental groups before and after the experiment.

Parameters	**Control group before the experiment started**	**Control group after the held experiment**	**Experimental group before the experiment started**	**Experimental group after the held experiment**
Sample volume	39	39	35	35
Average	12.85	13.46	13.70	15.03
Median	12	13	13	15

Table 4: The results of testing the hypothesis of the sample distribution normality.

Group	**Before the experiment**		
Control group	$\chi^2_{empirical}$ 16.64	$\chi^2_{critical}$ 19.68	Accepted hypothesis H_0
Experimental group	$\chi^2_{empirical}$ 17.60	$\chi^2_{critical}$ 18.30	Accepted hypothesis H_0
	After the experiment		
Control group	$\chi^2_{empirical}$ 12.56	$\chi^2_{critical}$ 18.30	Accepted hypothesis H_0
Experimental group	$\chi^2_{empirical}$ 9.96	$\chi^2_{critical}$ 19.68	Accepted hypothesis H_0

Table 5: The results of statistical test of hypothesis.

Before the experiment		
$t_{empirical}$ 0.8	$t_{critical}$ 1.99	Accepted hypothesis H_0
After the experiment		
$t_{empirical}$ 2.3	$t_{critical}$ 1.99	Accepted hypothesis H_1

But in the field of education it is possible to use them in the training of future IT professionals.

The study has demonstrated a number of advantages from the introduction of virtualization in the educational process using VirtualBox, in the discipline of “IP telephony in computer networks”:

- the ability to support different operating systems in order to provide support and simultaneous launch of different operating systems to establish network interaction for the implementation of IP telephony service;
- the ability to isolate potentially dangerous steps of the operator or software products. In this case, the virtual machine acts as a laboratory stand, which is fully controlled by the student;
- the ability to create the necessary hardware configurations for the implementation of network interaction in the study of the discipline of IP telephony in computer networks. As a part of the lab-

oratory workshop, it is necessary to use the specified hardware configurations while checking the performance of Asterisk servers in certain conditions. It can also be used to perform various practical simulations of software and hardware;

- virtual machines application provides significant opportunities for setting up IP telephony servers, you can create repositories of ready-to-use virtual machines with guest operating systems set up according to the needs of a specific laboratory task, and use for training purposes. The developed virtual machines can be used for experimental research in the field of IP telephony, because in case of damage to the system, its recovery from the saved state takes little time;
- a significant advantage for learning IP telephony in computer networks using virtual machines is the ability to run several virtual machines connected to a virtual network on one host at the same time. This feature provides significant capabilities for creating virtual network models among multiple systems on a single physical computer;
- Virtual machines increase student mobility, they can be exported and moved to another computer, and there the virtual machine can be started immediately. This is a significant advantage of virtualization during the SARS-CoV-2 pandemic, when students have to study remotely. Each student can have his own virtual laboratory;
- while using virtual machines in the training of IP telephony control over the creation of backups, creating snapshots of virtual machines and recovery from failures significantly increase.

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Application of R Programming Language in Learning Statistics

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Keywords: R Programming Language, Statistics, Statistical Data Analysis, Teaching Statistics.

Abstract: The study examines the problem of teaching statistics to future programmers. The theoretical content of teaching statistics has undergone significant development and requires a change in its focus on the practical field, even while studying at a higher education institution. It is determined that the improvement of teaching statistics to students requires moving from theoretical teaching methods to the practical solution of applied problems and shifting of emphasis from the process of statistical calculations to the analysis and results interpretation. The research allowed establishing that the training of statistics of future programmers should be based on the use of applied system of tasks developed with the help of real data sets obtained as a result of statistical research. Such tasks allow increasing the educational motivation of students in comparison with synthetic examples, which are usually used in the study of statistics. The research has analyzed the software for statistical data analysis as well as identified features of its application in the learning process. It is offered to use a specialized programming language R as the main learning tool.

1 INTRODUCTION

During the "information explosion" there is a problem in the statistical education of the society. The study of statistics is an important component of the educational programs for training specialists in the field of IT. While teaching courses on statistics teachers face a significant number of problems such as: different levels of knowledge, low level of motivation, lack of understanding by students of the necessity to study statistics for application in the future profession (Zieffler et al., 2008).

There have been serious concerns about the future of statistics as a discipline recently. Cox (Cox, 1997), Moore (Moore, 1997), Smith and Staetsky (Smith and Staetsky, 2007) raise many questions about the need to improve the goals, content, methods and forms of teaching statistics.

Many scientists have conducted researches that have studied the problems of teaching statistics. Recommendations for teaching statistics in the educational institutions of various types are given in (Ben-Zvi and Garfield, 2004; Biehler et al., 2018; Bishop et al., 1996; Garfield and Ben-Zvi, 2008; Langrall et al., 2017; Shaughnessy, 1992, 2007). In the studies (Garfield and Ben-Zvi, 2008; Watson et al., 2013) it was offered to move from the theoretical learning to the application of statistical methods in practice during learning.

Nicholl (Nicholl, 2001) notes that over the past 50 years, the theoretical content of teaching statistics has developed significantly, but this process has been uncontrolled, by introducing new concepts into the content. As a result, the content of teaching statistics as a discipline has provided teachers with a large number of theoretical concepts aimed at improving the theoretical training of students. All this does not contribute to the development of students' motivation and interest to study statistics. Rumsey (Rumsey, 2002), Gal and Garfield (Gal and Garfield, 1997) draw attention to the problems of teaching statistics, and propose to change the training paradigm and direct its focus on the practical field, even during training in higher educational institutions.

Investments in education are seen as investments in production, where human capital is created. The World Economic Forum predicts that over the next five years, there will be a nearly six-fold increase in

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global demand for statistical data analysts.

According to the Modis survey (Modis, 2018), 97.44% of respondents (representatives of banks and industry) consider data analysis as a prospect for successful development in sales and marketing. However, the interest in interpreting the data is higher than in the calculations. 42% of respondents complain about the lack of qualified professionals who have methods of statistic data analysis in the labor market. 55% of respondents say that it is difficult to find specialists who can calculate and interpret the results.

Every day in the world large amounts of various data are generated, which are constantly increasing (Khomenko et al., 2020). Therefore, the demand in the labor market for data analysts and data researchers is constantly growing. Varian (Varian, 2017) notes that data analyst will become the most popular profession in the future.

Thus, improving the education of students in statistics requires moving from the theoretical teaching methods to the practical solution of applied problems and the shift of emphasis from the process of statistical calculations to the analysis and results interpretation.

To begin preparing an intellectually active, enriched with the knowledge and skills specialist, education must move from the reproductive to the innovative learning. Innovative learning is a creative combination of the traditional and new teaching methods, their choice for each discipline, based on its theoretical content and practical orientation (Kaminskaya, 2011). At the same time, it should be considered that while teaching educational material to students, it is important not only to form certain professional competencies, but also to adjust them to today's modern requirements. It means that the future specialists must be able to express their thoughts and concepts in words, understand the language of symbols, signs and schemes. This is not just the ability to think creatively, but also the ability to make extraordinary decisions and actions.

To organize innovative training of statistics in accordance with modern requirements, it is advisable to use special software for statistical data analysis. However, today there are specialized programming languages and environments that can be used to quickly and efficiently analyze data, interpret results and prepare conclusions as well as reports in various formats.

Thus, there is a contradiction between traditional approaches to teaching statistics and society's requirements for the level of modern IT specialists training in the field of statistical data analysis, as well as between the theoretical orientation of the content of statistics training and the need to train a specialist with applied tools and methods of statistical data analysis.

The article aims to justify the use of R programming language as a teaching method in learning statistics.

2 RESULTS

The following main methods were used in the research process: content analysis of scientific and methodical literature, generalization and systematization to clarify the state of the problem development; questionnaire of those getting higher education and initial statistical processing of the obtained results to clarify the current state of the researched problem; generalization of theoretical and practical data to justify the introduction of innovative approaches to the study of statistics by students based on the use of programming language R.

The process of teaching statistics to the students is associated with certain difficulties: the study material in this course contains a large number of definitions and formulas. At the same time, students need not only to reproduce them, but also to understand the meaning and be able to apply in practice. However, with the traditional organization of the educational process, practical tasks are far from the real economic, social and other processes that occur in real life. The analyzed data are generalized and do not allow to fully form students' understanding of the need and expediency of studying this discipline and the opportunity to implement the acquired competencies in their further professional activities.

Therefore, most students learn statistics in fragments, and do not form systemic knowledge as a result. In addition, mainly verbal presentation of information increases fatigue, resulting reducing productivity of the learning process (Fitsula, 2000).

The number of statistically educated people is decreasing. It is difficult for potential employers to find a specialist who will be able to perform statistical calculations without prior training and explanation. Therefore, there is a need to improve the content of teaching this discipline through the introduction of practical tasks.

Improving the content of the statistics course requires the introduction of changes in the methods and means of its teaching using innovative technologies.

Scientific innovations that promote scientific progress cover all areas of knowledge. There are socio-economic, organizational and managerial, technical and technological innovations. One of the types of social innovations is pedagogical innovation.

Pedagogical innovation is an innovation in the field of pedagogy, purposeful progressive changes that make stable elements (innovations) in the educational environment that improve the characteristics of both – its individual components and the educational system on the whole (Rapatsevych, 2006).

Pedagogical innovations can be carried out both with the application of the educational system's own resources (intensive way of development) and with the involvement of additional capacities (investments) – new means, equipment, technologies, capital investments, etc. (extensive way of development).

Kazakov (Kazakov, 2006) notes that the combination of intensive and extensive ways of pedagogical systems development allows to carry out so-called "integrated innovations", which are built at the junction of various, multilevel pedagogical subsystems and their components.

The main ways and objects of innovative transformations in the teaching of statistics are:

- making concepts and strategies for the development of statistical education (Tishkovskaya and Lancaster, 2012);
- updating the content of statistics training;
- change and development of new learning technologies;
- improving the training of IT specialists in the field of statistical data analysis;
- designing new models of the educational process for teaching statistics;
- improving the monitoring of the educational process and student learning;
- new generation electronic teaching aids development.

Innovation can take place at different levels. The highest level includes innovations that affect the entire pedagogical system.

Kulinenko (Kulinenko, 2013) notes that while organizing the innovation, it should be considered that:

- innovative ideas must be clear, convincing and adequate to the real educational needs of man and society, they must be transformed into specific goals, objectives and technologies;
- innovation activity should be morally and materially stimulated, legal support of innovation activity is necessary;
- not only results are important in pedagogical activity, but also ways, means, methods of their achievement.

The current problems of teaching statistics in modern higher educational institutions include the review of experience associated with the intensification of learning. One of the main teacher's tasks is to teach students to obtain the necessary information independently, to teach them to consciously process the obtained information (Pavlenko and Pavlenko, 2021). In order for them to be able to study the teaching materials on their own, the materials need to be designed primarily for students and not for teachers.

Possibilities of "Statistics" discipline for experts in the field of IT consists first of all of that knowing mathematical language and modeling that will allow the student to be better guided in forecasting of economic, social, technical and other processes; secondly, that statistics by its internal nature has rich opportunities for the formation of students algorithmic thinking.

Future IT professionals must not only know the theoretical foundations, but also be able to apply the means of automating statistical analysis. Such tools include specialized statistical software packages and programming languages.

Statistical packages on the basis of functionality can be divided into 3 main groups.

1. Universal statistical packages Statistica, SPSS, Statgraphics, STATA, Stadia, SYSTAT, S-PLUS and MS Excel. These packages are not targeted at a specific subject area and can be used to analyze data from different industries. Typically, they offer a wide range of statistical methods and have a relatively simple interface.

   It is recommended to work with such packages for starter users who have only basic knowledge in the field of statistics, as well as experienced users in the initial stages of working with data, when statistical methods that will be used to address a particular issue are not clearly defined yet. The versatility of the universal package allows holding a pilot analysis of different data types using a wide range of statistical methods. The vast majority of existing universal packages has much common functionality and is similar in the composition of the built-in statistical procedures.
2. Professional statistical packages such as SAS or BMDP. Professional packages, in the contrast to the universal ones, allow you to work with extremely large amounts of data, apply highly specialized methods of analysis and create your own data processing system. As a rule, such packages are complex and should not be used in the educational process.
3. Specialized statistical packages BioStat, Datas-

tream, Datascope, etc. were designed for statistical analysis in specific areas of activity, which use special methods of statistical analysis, usually not presented in the universal packages.

Specialized packages allow analysis using a limited number of specialized statistical methods or are used in a specialized subject area. As a rule, such statistical packages are handled by specialists who are well acquainted with data analysis methods in the field to which the package is focused. For example, the BioStat statistical package was created to analyze data in the field of biology and medicine.

Most of the existing statistical packages have a flexible modular structure that can be supplemented and expanded owing to the custom modules that are optionally purchased or freely available on the Internet. Such flexibility allows you to adapt packages to the needs of a particular user.

Statistical packages are just the tools for an experienced professional. If the specialist does not have sufficient knowledge and competencies, then, even the most advanced software product will not allow holding quality data analysis. However, the wrong software, which does not contain the required set of statistical procedures, can make the work of even an experienced specialist more difficult.

Therefore, during the training of IT specialists it is necessary to acquaint those who get higher education with the available statistical packages and their characteristics, but the application of specialized programming languages is closer and more understandable for the students while conducting statistical data analysis.

For statistical data analysis it is possible and appropriate to use R and Python programming languages.

We will consider the features of the programming language R. The language R is a powerful high-level object-oriented programming language and environment for statistical calculations and visualization of source and calculation data, which allows you to solve many problems in the field of data processing. It's a free open source program under GNU GPL designed to run common operating systems (Windows, macOS, Linux).

Tens of thousands of specialized modules and utilities have been developed for this language. One of the most important features of the programming language R is the efficient implementation of vector operations, which allows the application of compact notation while processing large amounts of data. All this makes R an effective tool for obtaining useful information from large amounts of various statistics, including Big Data.

The R language is a convenient and effective tool for teaching statistical analysis, data processing and visualization.

It is also possible to use the Python programming language in the field of data analysis and interactive research calculations with results visualization. Python is an open source object-oriented programming language. The relatively recent advent of improved libraries for Python (primarily pandas) has made it a serious competitor to the R language for statistical data analysis. Combining with the benefits of Python as a universal programming language makes it an excellent choice for creating data processing applications.

So, the use of a specialized programming language as a learning tool contributes to the development of statistical data analysis skills as well as the development of algorithmic thinking of future IT professionals.

In order to study the relevance of the problem of scientific research, a ascertaining experiment was conducted among students of IT specialties. The issues that allow finding out the opinion of higher education students on the problem of improving the methods of teaching statistics to future IT professionals were studied.

The results of the ascertaining experiment are presented in percentages and indicate the number of positive answers to the questions. The survey was organized using GoogleForms. 83 students majoring in 015 Professional Education (Digital Technology) and 015 Professional Education (Computer Technology) took part in ascertaining experiment.

2.1 Declared Interest of Students in Studying the Course of Statistics

In this block students were asked two questions. You can see the results of the answers to the first question of the survey in figure 1. The analysis of answers allows establishing the level of awareness of students in the demand for specialists in the labor market who know how to analyze data.

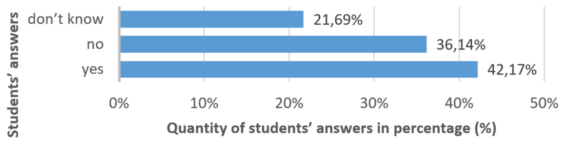

Figure 1: Results of answers to the question regarding students' awareness in the demand for the specialists on data analysis in the labor market.

Analysis of students' answers allows us to conclude that the majority of respondents, 42.17% believe that a data analysis specialist is in demand in the labor market. This confirms the relevance and need to study the course of statistics for IT professionals.

The second question clarified which specialties in data analysis students consider the most relevant today. The results of the student survey are shown in figure 2.

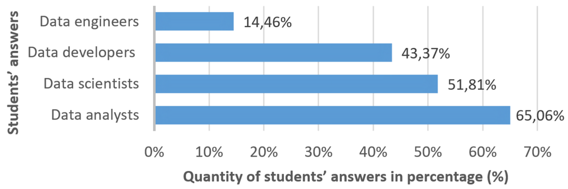

Figure 2: The results of questionnaire regarding students' awareness about modern professions on data analysis in the labor market.

The most famous profession among the future students programmers is the profession of data analysts (65.06%), in second place is the profession of data scientists (51.81%). These professions are known to more than 50% of students, which indicates their awareness and interest in this field.

So, based on the results of studying the answers to the questions of this block, we can draw the following conclusion. Training statistics of future IT professionals is relevant, because students are aware of the existence of professions in the field of data analysis and believe that they will need statistics in future professional activities.

2.2 Students' Opinion about the Need to Fill the Content with Tasks of an Applied Nature

Students were asked to answer open-ended questions: "Which subject area data analysis you are interested conducting in?" The students' answers showed that the most popular data for processing are data from sociology, medicine, engineering, economics and biology.

Also, the idea of what data students are interested in working with in practice was studied. The results of answers to the questions are shown in figure 3.

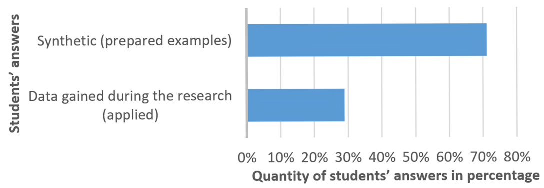

Figure 3: Students' opinion on data origin for practical tasks.

Among the surveyed respondents, 71.08% believe that data obtained as a result of practical research and having an applied nature are most attractive for them. This indicates the need to develop practical and laboratory work based on real data obtained from statistical studies.

2.3 Students' Interest in using Programming Languages and Software for Statistical Data Analysis

The purpose of the third block of questions was to study the opinion of respondents about the need and feasibility of using software and programming languages for statistical data analysis.

Students were asked the following questions: "Do you know programming languages with which it is possible to perform statistical data analysis (enter)?", "Which software product interface is more user friendly for you?", "Are you more interested in data analysis using special software or using a programming language?"

According to the first question, the opinions of the respondents were divided as follows: 55.42% indicated the programming language R, 28.92% indicated the Python programming language. Programming languages such as C++ (9.64%) and Java (6.02%) were also indicated (figure 4).

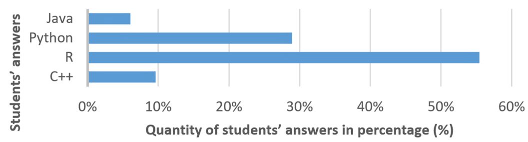

Figure 4: Respondents' answers to the question on convenience of program packages interface.

The obtained results allow us to state that the R language is the best known as a mean of statistical data analysis. So, we will use this programming language to solve application problems.

In choosing the convenience of the software package interface, respondents preferred MS Excel (56.63%), followed by Statistica software package (28.92%), followed by SPSS (14.46%) (figure 5).

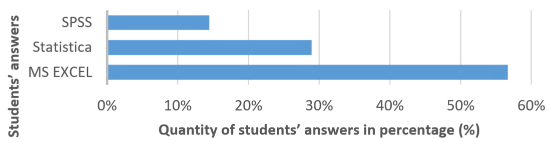

Figure 5: Choosing program packages for statistical data analysis.

So, the students will be asked to use MS Excel and Statistica for practical calculations.

According to the results of students' answers to the third question of this block, the programming language (57.83%) was chosen by the students as the main tool for organizing the training of statistical data analysis (figure 6).

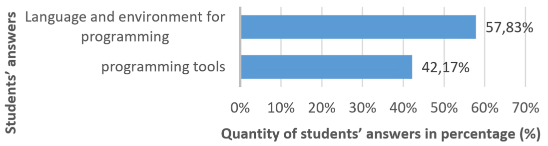

Figure 6: Respondents' answers regarding choosing the mean of solving the tasks of statistical data analysis.

So, students in the class will be asked to use the programming language R as the main tool for practical calculations. MS Excel and Statistica will be used as aids in statistical analysis.

3 USING APPLIED TASKS FOR TEACHING STATISTICS

Taking into account and summarizing the results of the study, in our opinion, it is advisable to build the content and structure of the course considering the wishes of students. In practical classes, tasks that are of a real applied nature and based on real statistics should be considered. One of the main teaching methods should be a practical method of learning based on programming. The means of statistical data analysis in practical classes can be both software tools for data analysis (MS Excel and Statistica) and the language and programming environment R.

A system of tasks has been developed for the course. Let's consider an example for training of the statistical analysis in the R environment. For carrying out the analysis we will take data from the website https://abit-poisk.org.ua, namely data concerning entrants for 2017. This site contains large amounts of data, for our example we will take only entrants who entered the Faculty of Physical and Mathematical Computer and Technological Education of Berdyansk State Pedagogical University in the specialty "Professional Education (Computer Technology)" and "Professional Education)", the level of "bachelor".

A total of 31 applications were submitted for these specialties. We will analyze these data, using descriptive statistics in R and present the results using the most common graphs in R when analyzing this data.

Step 1. We set the name, specialty, id, total score of the external evaluation, status (budget / contract), then enter the data into the table. We will set the value in the form of vectors with the command `c(''vector_value1'',''vector_value2'',...)`. We build the table from the received vectors by means of the command `> studentdata`. Commands for a table creation with the information about applicants:

```
> last_name <-c(''Shvachko'', ''Dybiaga'',
''Kartashov'', ''Sytosenko'',''Filipenko'',
''Klimenko'', ''Veretelnik'',  ''Diakov'',
''Salionov'', ''Bagnuk'', ''Kombarov'',
''Baranovsky'', ''Kiseliov'', ''Sakun'',
''Bova'', ''Potapova'', ''Kobzar'',
''Sementsov'', ''Cybulka'', ''Teplov'',
''Mitushkin'', ''Kartinik'', ''Gavrylenko'',
''Trotsenko'', ''Panchukov'', ''Kyslynsky'',
''Sagirov'', ''Korobov'', ''Shatalina'',
''Tichovod'', ''Popov'')
> specialty <-c(1,1,1,1,1,1,1,1,1,1,1,
1,1,1,1,1,1,1,1,1,1,1,1,1,1,2,2,2,2,2)
> id <-c(1,2,3,4,5,6,7,8,9,10,11,12,13,14,
15,16,17,18,19,20,21,22,23,24,25,26,27,28,
29,30,31)
> rating <-c(186,184,180,179,173,173,170,
168,167,166,163,162,160,156,148,145,145,
142,142,140,140,139,135,131,129,123,147,
146,140,136,128)
> status <-c(1,1,1,1,1,1,1,1,1,1,1,1,0,0,0,
0,0,0,0,0,0,0,0,0,0,0,1,1,1,1,0)
> studentdata <- data.frame(id, last_name,
 rating, status)
> studentdata
      id  last_name rating status
   1   1   Shvachko    186      1
   2   2    Dybiaga    184      1
   3   3  Kartashov    180      1
   4   4  Sytosenko    179      1
   5   5  Filipenko    173      1
   6   6   Klimenko    173      1
   7   7 Veretelnik    170      1
   8   8     Diakov    168      1
   9   9   Salionov    167      1
   10 10     Bagnuk    166      1
   11 11   Kombarov    163      1
   12 12 Baranovsky    162      1
   13 13   Kiseliov    160      0
   14 14      Sakun    156      0
   15 15       Bova    148      0
   16 16   Potapova    145      0
   17 17     Kobzar    145      0
   18 18  Sementsov    142      0
   19 19    Cybulka    142      0
   20 20     Teplov    140      0
   21 21  Mitushkin    140      0
   22 22   Kartinik    139      0
   23 23 Gavrylenko    135      0
   24 24  Trotsenko    131      0
   25 25  Panchukov    129      0
   26 26  Kyslynsky    123      0
   27 27    Sagirov    147      1
   28 28    Korobov    146      1
   29 29  Shatalina    140      1
```

```
30 30    Tichovod     136       1
31 31       Popov     128       0
```

Step 2. We will calculate the main statistical values: average, median, standard deviation, minimum and maximum value. The results of the main statistical values calculation:

```
> y <- mean(rating)
> y
[1] 153
> sd <-sd(rating)
> sd
[1] 18.03145
> var <-var(rating)
> var
[1] 325.1333
> mad <-mad(rating)
> mad
[1] 22.239
> min <-min(rating)
> min
[1] 123
> max <-max(rating)
> max
[1] 186
```

According to the results of the calculations, the following data were obtained: the average score of entrants with external evaluation is 153, the average difference between the scores of different entrants is 22 points, the lowest result (min) – 123 points, the best result (max) – 186 points.

Step 3. Let's construct a histogram of frequencies for external evaluation points using the command `> barplot` (figure 7):

```
> counts <- table(studentdata$rating)
> barplot(counts,
    main=''Frequency diagram'',
    xlab=''Rating'', ylab=''Frequency'')
```

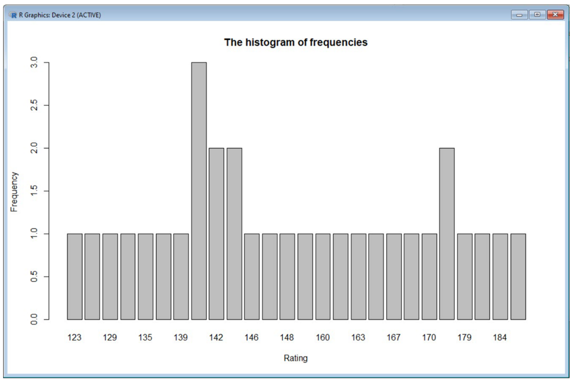

Figure 7: The histogram of frequencies for external evaluation points.

The histogram of frequencies shows that the largest number of entrants has a score from 139 to 142 points, as well as the fact that the vast majority has a unique score with EIT, which is no longer repeated.

Step 4. We construct histograms of points / frequencies with a normal distribution curve. With this purpose we use the command `> box`. We will build: on the *x*-axis – the parameter rating, and on the *y*-axis – the frequency of the score in the table (figure 8):

```
> box()
> library(plotrix)
> x <-studentdata$rating
> h <-hist(x, breaks=12, col=''darkblue'',
  xlab=''ZNO score'', main=''Frequencies
  histogram with the curve of distribution``)
> xfit <-seq(min(x), max(x), length=40)
> yfit <-dnorm(xfit,mean=mean(x),sd=sd(x))
> yfit <-yfit*diff(h$mids[1:2]*length(x))
> lines(xfit, yfit, col=''red'', lwd=3)
```

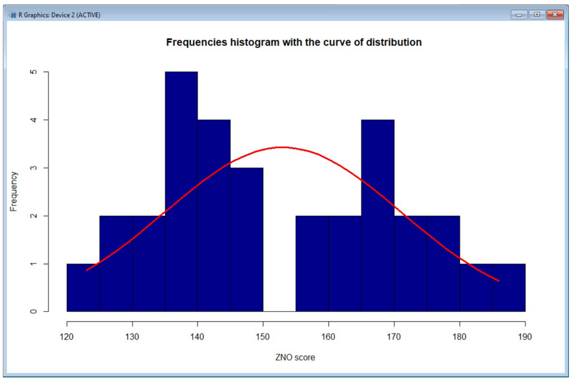

Figure 8: Frequencies histogram with the curve of distribution.

The distribution histogram shows that the data on the scores of applicants are not the subject to the normal law of distribution. We have a lot of "average" entrants, i.e. those who passed the external examination from 135 to 145 points. There are also those who passed 165 points, i.e. entrants with a "sufficient" level. There are very few who scored more than 180 points.

Step 5. We construct a diagram of the nuclear estimation of the density of values for external evaluation points using the command `> box` (figure 9):

```
> box()
> par(mfrow=c(2,1))
> d <- density(studentdata$rating)
> plot(d)
```

The nuclear density estimation diagram shows that the highest density is observed in the range from 130 to 155 points. That is, in this interval, based on the graph, the values differ by 25 points, then, if you take the full table, they differ by 22 (see standard deviation).

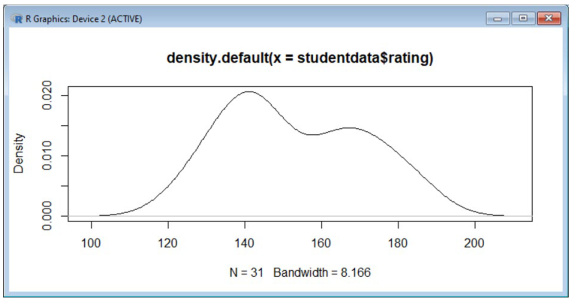

Figure 9: The diagram of nuclear density estimation.

As a result of solving applied problems using theoretical knowledge from different sections of statistics, students will not only master the skills of using statistical methods, but also develop the ability to interpret the results and predict the studied processes. It should be emphasized that the use of programming as a practical teaching method will allow students to improve their knowledge and skills in the field of programming as well as the use of algorithms and design patterns.

Using real data for statistical analysis, students will be able to understand the need and feasibility of statistical research in future professional activities.

One of the problems of using application tasks with real data is the selection and use of data sets. Much of the datasets are closed and inaccessible for free research and use. However, there are organizations that provide free access to data:

- World Bank Open Data (https://data.worldbank.org/) provides more than 3,000 sets of economic and social data on various indicators. Data can be downloaded in csv and xml formats. The service supports API access, which allows you to automate data downloads using the programming language R.
- The unified state web portal of open data (https://data.gov.ua/) contains 15 categories of data sets that are constantly updated. Datasets are available for download in Excel, csv, json and xml formats. All data are available from Creative Commons Attribution 4.0 International license.
- The official page of the All-Ukrainian Population Census (http://database.ukrcensus.gov.ua) provides access to information on the population living in the country, socio-economic characteristics, and demographic indicators, level of education, national composition and language characteristics. Datasets can be downloaded in txt, csv, html formats.
- Open World Health Organization data repository (https://www.who.int/data/gho/). The site provides datasets on the health status of citizens of World Health Organization member states. Datasets are divided into over 100 categories. Data can be downloaded in Excel format or use the API for direct access to data.
- UNICEF Dataset (https://data.unicef.org/) collected relevant data on education, child labor, child disability, infant mortality, maternal mortality, water and sanitation, pneumonia, malaria and more. Datasets are available in Excel and csv formats.
- Registry of Open Data on AWS (RODA) (https://registry.opendata.aws/) contains data located on AWS servers. The service offers access to over 200 datasets. There is a page with additional information, usage examples, license information, and more for each data set. Using the wide range of computing products offered by AWS (Amazon EC2, AmazonAthena, AWS Lambda and Amazon EMR), it is possible to share data in the cloud. This allows users to spend more time analyzing data rather than collecting data. When using data sets hosted on AWS, it is necessary to consider the type of license of each specific data set, as they belong to different agencies, government organizations, researchers, businesses and individuals.
- Data.gov (https://www.data.gov/) provides open data sets of the US government. The resource contains more than 200,000 data sets from various sources: federal agencies, states, counties, cities, etc. Data can be obtained in various formats, including Excel, csv, json, xml.
- The GroupLens Research (https://grouplens.org/) provides several sets of movie ratings data provided by MovieLens users. The kits contain movie ratings, movie metadata (genre and release year), and user demographics (age, gender, and occupation). Such data can be used to develop a recommendation system based on regression analysis.
- Open data sets Yelp (https://www.yelp.com/dataset) is a subset of our businesses, reviews, and user data for application in personal, educational, and academic purposes. Available as JSON files, use it to teach students about databases, to learn NLP, or for sample production data while you learn statistics.
- Kaggle (https://www.kaggle.com/datasets) a social network for researchers, which provides access to various data sets for analysis and research. The convenience of Kaggle is that it is not just a data warehouse. Each data set brings together a community of researchers in which data are dis-

cussed and approaches to data processing are elucidated.

- Google Public Data Explorer (https://www.google.com/publicdata/directory) provides access to more than 130 datasets submitted by World Bank, U. S. Bureau of Labor Statistics, OECD, IMF and other organizations.

All considered services provide access to open data sets. This allows you to fill the content of teaching statistics for future programmers with the tasks of applied direction.

4 EXPERIMENTAL VERIFICATION OF THE EFFECTIVENESS IN THE USE OF APPLIED TASKS TO TEACH STATISTICS TO THE FUTURE PROGRAMMERS

Using programming language R and tasks of applied direction while training statistics with future IT specialists.

The main purpose of the pedagogical experiment is to test the hypothesis that the use of programming language R and applied problems in teaching statistics to the future IT professionals will help increase the educational motivation of students.

According to the hypothesis of the study, the experiment involved checking the level of motivation of students of IT specialties in the field of statistics based on the results of implementation of applied problems and programming language R. The experiment was conducted on the basis of Berdyansk State Pedagogical University. Students majoring in 015 Professional Education (Digital Technology) and 015 Professional Education (Computer Technology) took part in it.

Control and experimental groups were organized. In the control group, the educational process was carried out according to the traditional methods. This technique involved the use of specialized software (Microsoft Excel, Statistica, etc.) and synthetic tasks, the content of which did not take into account the specifics of future professional activities of students of IT specialties. The control group (CG) consisted of 42 students. The experimental group used application problems and the programming language R to solve them. The experimental group (EG) included 32 students.

During the formation of control and experimental groups, their alignment was carried out taking into account the initial level of educational motivation of students.

The success of the pedagogical research was ensured by the application of the standardized methods. This guaranteed the reliability of the results.

Experimental methods of teaching statistics of future programmers using professional tasks and programming language R was based on their application at all stages of learning: in learning new material as a motivating task, at the stage of consolidation, in independent work of students as a professionally oriented project.

An electronic learning tool has been developed for students programmers to provide information and methodological support for the statistics course. The development of an electronic tool takes into account students age and preparation level. The developed learning tool contains theoretical materials, tasks for practical implementation, visual materials with examples of the application of the programming language R, a guide to the commands of the R language and a list of recommended reading. The e-learning tool is available on the Internet at the link https://r.ktuni.bdpu.org/.

In order to test the effectiveness of the implemented experimental training, the level of educational motivation was chosen as a criterion. To assess the dynamics of changes in motivation to study statistics, future IT specialists used the method of Rean and Yakunin (Il'in, 1998) aimed at diagnosing educational motivation in general in order to identify the predominant types of motives for learning. The technique allows identifying the predominant type of motives and to trace the dynamics of changes in the structure of educational motivation. The methodology is standardized and involves the study of 16 types of educational motives of students.

Positive motivation for learning ensures the successful formation of knowledge and skills. High positive motivation can compensate for insufficiently high abilities of students. With the right choice of means of motivation for learning, there is a positive pedagogical influence. Focusing only on "negative" motives (avoidance, fear of failure, fear) is always less effective than "positive" ones. In our study, we will determine the impact of the developed system of tasks on the level of educational motivation of students.

Table 1 presents the results of calculating the average scores for each type of educational motives on the scale of Rean and Yakunin (Il'in, 1998). Comparative analysis of table 1 allows us to conclude that before the experiment the levels of educational motives of students in the control and experimental groups did not differ. After the experiment in the experimental

Table 1: The results of students' questionnaire according to the methods of Rean and Yakunin (Il'in, 1998).

Educational motivation	**Before the experiment**		**After the experiment**	
	CG	**EG**	**CG**	**EG**
1. To become a qualified specialist	6.6	6.6	6.7	6.8
2. To get the diploma	6.7	6.6	6.2	6.8
3. To continue successful studies at further courses	5.6	6.3	6.0	6.2
4. To study successfully, to pass exams for "good" and "excellent" marks	6.0	5.3	4.5	6.2
5. To get constant scholarship	5.5	5.2	4.9	5.5
6. To gain deep and profound knowledge	6.0	6.3	6.3	6.8
7. To be always ready for classes	4.5	4.5	5.0	5.2
8. Not to give up learning the subjects of the educational cycle	5.5	5.6	5.5	6.5
9. Not to lag behind the classmates	6.0	5.6	5.5	5.8
10. To provide future successful professional activity	6.8	6.6	6.5	6.9
11. To execute pedagogical requirements	5.0	4.7	5.2	5.5
12. To get teachers' respect	4.8	5.2	3.6	4.9
13. To be an example for the classmates	3.2	4.7	3.5	4.3
14. To gain parents' and relatives' respect	4.5	4.8	5.0	6.6
15. To avoid condemnation and punishment for bad studying	4.1	4.9	5.0	4.5
16. To get intellectual satisfaction	4.9	4.91	4.5	6.6

Table 2: Statistical comparison of the students of control and experimental groups educational motivation levels before and after the experiment.

Before the experiment			**After the experiment**		
W_{emp}	W_{crit}	**Taken hypothesis**	W_{emp}	W_{crit}	**Taken hypothesis**
0.1508	1.96	H_0	2.186	1.96	H_1

group there is an increase in the levels of the internal educational motives of students. In general, the level of educational motivation in the experimental group is higher than in the control group, except for the motives of avoiding failure and punishment.

Table 2 shows the results of statistical comparison of the control and experimental groups before and after the experiment. The following statements were formulated as working hypotheses: H_0 – levels of learning motivation in the compared groups do not differ; H_1 – levels of motivation to learn in the compared groups differ. The Mann-Whitney U-test was used to determine the difference between the samples. This is a non-parametric statistical criterion used to estimate the difference between two samples at the level of any qualitatively measured trait. It allows you to detect differences in the value of the parameter between small samples.

Statistical analysis allows us to conclude that at the level of significance $\alpha = 0.05$ the initial states of the experimental and control groups (before the experiment) coincide. At the end of the experiment, the levels of educational motivation differ.

So, the results of the study indicate that the hypothesis of the study was confirmed, namely the introduction of statistics of the R programming language and applied problems in the learning process helps to increase the level of educational motivation of future IT professionals.

5 CONCLUSIONS

During the research the introduction of innovative approaches to the study of statistics has been theoretically substantiated. The conducted research allowed establishing that the training of statistics of future programmers should be based on the use of applied tasks developed with the help of real data sets obtained as a result of statistical research. Such tasks allow increasing the educational motivation of students in comparison with synthetic examples, which are usually used in the study of statistics.

Datasets for statistical analysis are a source of applied tasks. Access to data sets on the Internet is free. Therefore, the development of practical and laboratory work for future IT professionals should include tasks that will contain real data from the following subject areas: sociology, medicine, engineering, economics and biology.

Using the programming language R to teach statistics to the future programmers allows you to use the method of practical training based on programming. This approach involves students in familiar to them practical activities and programming. Therefore, we propose to use the R language and programming environment as the main learning tool. MS Excel and Statistica software packages should be used as teaching aids.

In further research it is planned to develop a methodology for the implementation and application of programming languages R and Python for statistical data analysis.

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Development of Media Education in Ukraine: Current State and Modern Requirements

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Abstract: In order to perform professional functions in the modern educational media space, the future computer science teacher must have skills of working with information and communication technologies, be aware of the methods of teaching educational material using media, be able to develop critical and analytical thinking and apply multimedia technologies in the educational process. The article focuses on the peculiarities of the introduction media education in Ukraine and highlights the importance of media education development. The authors emphasizes the importance of media education and media literacy, which open up many opportunities for both students and teachers. As a result, the teacher develops the ability to assess information security, competently use sources of information, assess the reliability, see the correlation of information and knowledge, and properly organize the information process. Media education opens up great opportunities, helps to develop intellectual and creative potential, as well as critical thinking. The article describes the criteria for the future computer science teachers' media competence development.

1 INTRODUCTION

It goes without saying that our time is called the epoch of the information revolution. Rapid development of new technologies is causing an avalanche of information. Humanity is constantly evolving. In addition, the pace of change is steadily accelerating. It is becoming increasingly important for both the individual and the country to be able to respond to these changes so as not to stay away from the progress.

But, of course, it does not mean that people need to hide in a shell and isolate themselves from information flows. Nowadays, it is simply impossible. They need to be able to work with information. This is the focus of media literacy classes, which have been a part of the school curriculum in the United States, Great Britain, Germany, Australia, and Northern Europe for several decades. Finally, Ukraine has joined this movement. We have to prepare children for the successful development of the world. Today the most important component of this mastery is the ability to work competently with information (Ivanov and Volosheniuk, 2012).

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Problems of media education and media literacy attract the attention of representatives of various sciences (Bondarevskaya et al., 2017; Yankovych et al., 2019; Tereshchuk et al., 2019; Krylova-Grek and Shyshkina, 2020; Pokulyta and Kolotylo, 2021). The reason of it is not only that media literacy is an important component of the information society, but also that it has an interdisciplinary nature. To understand the processes, taking place in the modern media environment, young people, including teachers, should have special knowledge, communication and information skills, ability to critically analyze (i.e. have media literacy), which can be formed through organized and focused media education.

According to the logical conclusions of modern researchers of media education, there exists a need to develop a new more modern concept that combines media and information literacy. It should be borne in mind that media education policy has quite obvious national features. After all, the current course of modernization of media education is impossible without a media-competent person who is knowledgeable about information on current events, phenomena, and trends. In Ukraine, the development of media education policy is impossible without a scientific analysis of the situation, clarification of concepts, devel-

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opment of modern concepts, standards, and markers. The most important criterion for the effectiveness of media education development is the level of competence of those who take responsibility for its implementation. Unfortunately, in this field, which scientists are actively working on, there appear some problems: we need a massive increase in the competence of heads of departments and agencies, officials of various levels, administrative staff in the field of media, mass communications and information culture.

The study of this issue is impossible without the contribution of scientists who focused their research works on identifying the fundamentals of media education and media literacy. For our research the works (Buckingham, 2020; Considine, 2002; Masterman, 2013; Nazarov et al., 2020; Onkovich, 2013; Sharikov, 2021) are of great value. Research works of ascertaining character, which contain information on the perception of media texts in different countries and by different age categories, on the criteria and levels of audience development are done by Levshina (Levshina, 1978), Tyner (Tyner, 2020) etc.

2 FEATURES OF THE INTRODUCTION OF MEDIA EDUCATION IN MODERN SOCIETY

Nowadays, a person is required not to master some special information, but to be able to navigate information flows, be mobile, learn new technologies, self-learn, search for and use missing knowledge or other resources. In this regard, there appears an issue of studying the development of media education, which main task is "to prepare new generation of people for the life in modern information conditions, for high-quality perception of information and mastering communication methods through technical means and modern information technologies" and to develop Soft skills (sociability, self-presentation, ability to work in a team). It is worth noting that in most Ukrainian higher education institutions, media education still remains fragmented, which actualizes the desire to implement an effective media education system in Ukraine which is able to provide the improvement of the educational process and guarantee the European quality of higher education. Media education contributes to the establishment of democracy, education of media literate individuals who are able to think critically, develop creative skills and are ready to live in a modern information society (Sheina, 2017).

The key skills, that are now considered to be a basis of education and should be embedded in the curricula, are available to every modern person. After all, humanity is developing rapidly, replacing many hard skills by robotics, neural networks, and artificial intelligence. There is a tendency that sooner or later in many areas of their activity people will be replaced by artificial intelligence. Neural networks, which are able not just to communicate with a person, answering questions, but to joke in response and even anticipate the continuation of the dialogue; works of art created by artificial intelligence, cars with full autopilot – all these factors become a reality that cannot be ignored. In the future all the physical capabilities of a man can be replaced by a robot, but artificial intelligence lacks some human skills (the robot cannot think emotionally), so a person still has some preferences such as emotions and skills of professional communication. This means that media education, as a process that allows you to immerse yourself in the training of key skills, is an educational process that is most relevant today. For example, some leading European schools have integrated the Soft skills into the learning process. There is a focus on serious theoretical and practical training in all areas of media education, which makes educational process an exciting and effective one.

The relevance of media education depends on the rapid development of informatization and globalization which have made our perception of the world dependent on how it is presented by the media. Unfortunately, the latter doesn't respond properly to the growing responsibility: the information is poorly checked, it contains elements of manipulation and fraud. In these conditions, media education is a way for people to develop the ability to protect themselves from unscrupulous media information.

Media education as an intellectual and communicative network can be researched from several points of view. In particular, on the one hand, we can talk about the peculiarities of the network of mass media (global, state, regional, etc.). However, on the other hand, a network of purely media education is being more and more discussed, as it covers an increasing scope of information and educational space and is aimed at personal development. Many scholars consider media education as a process of learning, mastering media literacy. Media literacy is the ability to use, analyze and evaluate media products. Some researchers define "media literacy" as a key concept of media education, while the concepts of "media literacy" and "media education" are considered by many educators and researchers to be synonyms. In fact, media literacy makes it possible to use media sources more effectively, which generally increases not only media competence but also competence in its broader sense (Onkovyc, 2008).

Fedorov (Fedorov, 2014) gives the following definition of media education: it is a process of personal development with the help and on the material of the media in order to form a culture of communication with the media, develop creative, communicative skills, critical thinking, skills of perception, interpretation, analysis and evaluation of media texts, to acquire different forms of self-expression with the help of media techniques.

Media education should be resulted in an increase of the level of media literacy, which is a set of motives, knowledge, skills and abilities that contribute to the selection, use, critical analysis, evaluation, design and dissemination of media texts of various forms, genres; it also promotes the ability to analyze complex media processes in the society.

Media education is a part of the basic rights of every citizen in every country of the world to freedom of expression and access to information; an instrument for the development and observance of democracy. Media education is related to the study of all media communications and includes the printed word, graphics, sound and moving images delivered by any technology. Media education provides an opportunity to understand the methods of mass media used in the society, and to master the skills of using these media in communication with others (Ivanov and Volosheniuk, 2012).

One of the most reputable media educators and media theorists Masterman (Masterman, 1993) has substantiated seven reasons for the priority and relevance of media education in the modern world:

1. High level of media consumption and saturation of modern society with mass media.
2. Ideological importance of the media, and its impact as an industry on the public consciousness.
3. Rapid growth in the amount of media information, strengthening mechanisms for its management and dissemination.
4. Intensification of media penetration into the main democratic processes.
5. Increase in the importance of visual communication and information in all areas.
6. Need to teach schoolchildren/students with a focus on compliance with future requirements.
7. Growth of national and international processes of information privatization.

Onkovych (Onkovych, 2007a) notes that the stakeholders of media education should not be limited only to students: media literacy is also needed by adults. In addition, she reasonably draws attention to the need for independent media education. In her theoretical concept Onkovych (Onkovych, 2007b) puts forward the ideas of media didactics.

Since children and young people are most exposed to information, adults (in particular, teachers and parents) must be able to manage the process of a child's entry into the information world. In order to do this, the adults themselves have to first learn to use information flows properly, to master the means of communication. Only under these conditions teachers and parents will be able to effectively prepare children and youth for conscious, competent, and most importantly, safe use of information resources. They should also develop the culture of information users.

Therefore, today media education is a rather serious and deep issue of education development in general, it is a part of the educational process aimed at the formation of media culture in the society, preparation of individuals for the interaction with the modern media system – and not only with traditional media (printed word, radio, cinema, television), but also with the latest technologies (communication via computer and the Internet) (Naidenova, 2013).

Accordingly, the education system faces the task of forming and developing students' competencies that allow them to effectively interact with numerous information sources and flows, analyze the information received, assess its reliability and usefulness in solving various life problems. Media education has to achieve this goal. Concept of implementation of media education in Ukraine defines media education as "a part of the educational process aimed at the formation of media culture in the society, preparation of individuals for safe and effective interaction with the modern media system, including both traditional (printed word, radio, cinema, television) and new (computer-mediated communication, Internet, mobile telephony) media" (Institute of Social and Political Psychology of the National Academy of Pedagogical Sciences of Ukraine, 2018). Therefore, the immediate task of media education is the formation of such important skills as structuring and analysis of information received from various sources, determining the reliability and quality assessment, highlighting the most important aspects of media messages.

The introduction of media education in Ukraine is also due to the urgent task of our country's entry into the single European educational and information space. It should also be noted that it is in European countries (along with Canada, the United States and Australia) that the issue of media education is traditionally given the most attention.

Media education in Ukraine is currently at the beginning of an active phase of its development. In June, 1999 according to the resolution of the Academic Council of I. Franko Lviv National University, Institute of Ecology of Mass Information was founded. Its founders consider media ecology as a synthesis of philosophical-academic and purely applied directions of work connected with neutralization of pathogenic information streams. Research topics required an interdisciplinary approach and were mainly focused on the training of media professionals. Ten years later, in 2009, at V.N. Karazin Kharkiv National University a new Department of media communications was opened and an experimental Master's program was launched.

Nowadays, media ecology is increasingly being introduced into teaching practice in higher and secondary schools. There are also positive changes in conceptual approaches that meet European and global trends: if at first the attention of domestic experts was focused on the "detrimental impact of the media and the Internet", now positive approach is becoming more common, which primarily involves learning to interact effectively with various types of information (including protection against possible negative impact).

Since 2010, the already mentioned Concept of implementation of media education in Ukraine (Institute of Social and Political Psychology of the National Academy of Pedagogical Sciences of Ukraine, 2018) came into force. Its aim is "to promote the development of an effective media education system in Ukraine in order to ensure comprehensive preparation of children and youth for the safe and effective interaction with the modern media system, development of their media awareness, media literacy and media competence in accordance with their age and individual characteristics". By 2020, the concept envisages the implementation of the experimental phase, the gradual introduction of media education and standardization of requirements (2014–2016) and further development of media education and completion of its mass implementation (2017–2020).

Priority areas for the development of an effective media education system in Ukraine include "the creation of a school media education system, which provides for the development of psychologically sound primary school curricula for integrated education, promoting the integration of media education elements into various subjects syllabi, design of optional media education programs for adolescents" and comprehensive training of the teaching staff (Institute of Social and Political Psychology of the National Academy of Pedagogical Sciences of Ukraine, 2018).

In this regard, it is worth noting a very positive trend – the introduction of media education in the domestic education system is planned in close connection with existing courses. The provisions of the Concept have already been quite actively implemented in practice. A positive fact is that media education is implemented in cooperation with the Ministry of Education and Science of Ukraine, scientists of the National Academy of Educational Sciences of Ukraine and representatives of professional public organizations, especially the Academy of Ukrainian Press, which, in particular, did a great part of the work on the textbook "Media Education and Media Literacy" (Ivanov and Volosheniuk, 2012), which was specially designed to provide an appropriate course in higher education institutions and in the system of postgraduate teacher training.

Based on the research of scientists, the stages of formation of future computer science teachers' media competence in the process of their professional training in pedagogical universities have been identified.

The *first stage* includes the formation of motives and value orientations, and consists of the following operations: motivation to action, understanding the significance of the problem, identification of motives and their consolidation.

The *second stage* involves the development of future computer science teachers' ability to comprehend the content of the media competence formation. It consists of theoretical, research-reproductive and interpretive-creative periods. Theoretical period performs an informational, orientation and developmental function and is aimed at mastering the general content of media competence through such forms as lectures, seminars, consultations, interviews, explanations, problem-based presentations of the material and such teaching aids as syllabi and videos. Research-reproductive period is characterized by an unconscious manifestation of media competence. So that students will be able to outgrow this phenomenon, the teacher uses such forms as practical classes, lectures, seminars, consultations, trainings, explanations, learning experience, project works and such teaching aids as publications, videos, various media texts, etc.

Interpretive-creative period of the stage of mastering the content of the formation of future computer science teachers' media competence performs developmental, educational and training functions. It is carried out in order to gain experience in working with the media through the use of such forms as practical and laboratory classes, future computer science teachers' independent work in the process of their studying the professional-oriented disciplines, methods of modeling, problem and business games, etc.

The *third stage* deals with monitoring the process of formation of future computer science teachers' media competence during the period of their training.

The *fourth stage*, evaluative-corrective, involves the collection and accumulation of data on the level of media competence formation with further processing and analysis of data in order to identify the need for corrective actions.

In order to identify the effectiveness of the introduction of media education and formation of future computer science teachers' media competence, it is necessary to single out the components, criteria, levels and indicators of the formation of future computer science teachers' media competence.

It should be noted that in the scientific literature the problem of criteria is solved ambiguously. Kazakova (Kazakova, 1999) shows a lack of generally accepted criteria for "effective pedagogy" or the ways to determine the teachers and students' "quality of work", criteria for the effectiveness of each stage of personality development.

Chechel (Chechel, 1998) has defined the criteria as follows: "These are the properties of the object which provide it with an interconnected system of characteristics; that is why they become a subject for evaluation. It is possible to detect such a system, only on the condition of using a system-structural approach". The following requirements are set for the criteria:

a) objectivity;
b) stability and sustainability;
c) recurrence in the subject;
d) the ability to establish the degree of conformity of the subject to its ideal.

Gal'perin (Gal'perin, 2012), Podlasyi (Podlasyi, 1982), Usova (Usova, 2002) etc. have established various criteria for the formation of educational and cognitive skills. "Since each activity consists of a system of elementary actions and operations, composition and quality of operations, awareness of them, completeness and coagulation can be identified as the main criteria common to all cognitive skills" (Usova and Bobrov, 1987).

Scientists, who have studied the formation of professional skills, identify different criteria: Andrukhiv (Andrukhiv, 2008) – value-semantic, action-related, and cognitive criteria; Kuchugurova (Kuchugurova, 2006) – awareness of actions and their correctness; Suvorova (Suvorova, 1999) – degree of awareness of the actions performed, quality of actions performed, ability to apply skills in a new changed environment; Sukhodolsky (Sukhodolsky, 2008) – criteria of axiology, variability, motivation.

Taking into account the analysis of research done by media educators (Sysoieva, 2011; Bondarenko, 2003), it should be noted that the classification of levels of media competence can be even more detailed. One of these options is proposed by Khilko (Khilko, 2001):

1) recreational and hedonistic level of media perception (limited by entertaining motivation, aesthetic comprehension of the image);
2) household level (household, utilitarian motivation and corresponding characters);
3) aesthetic level (personal motivation, aesthetic comprehension of the image);
4) interpretative level (revealing the personal meaning and spiritual content of the piece of work, a vivid expression of inner vision);
5) microsocial level (manifested in the connection with the microenvironment, psychological motivations of the characters are given, connection with the perception of works by a particular audience is established);
6) macrosocial level (provides a critical analysis of the problem and its deployment in time and space, orientation for the society);
7) level of artistic image awareness (detailed description of the screen image, its components, selection of semantic units of the story);
8) level of the author's concept understanding (the ability to draw conclusions about what idea the author wanted to convey, based on the system of artistic perception of the piece of work);
9) level of personal concept emergence (autonomous) and the formation of autonomous vision: individual conclusions on the problem touched upon by the author and polemical dialogue with the author's concept.

After analyzing the scientific and pedagogical literature, we have come to the conclusion that there are several recurring criteria among mentioned above: motivational (motivation to develop the skills, awareness of the importance of these skills in the structure of the professional activity), action-related (level of skills necessary for professional activity, professional literacy, ability to transfer skills to changing situations), personal (formation of professionally significant traits of personality, character traits).

Based on this, let's take these criteria as a foundation, but clarify them taking into account the specifics of organizational and pedagogical activities. Assessment of the future teacher's work is complicated by the creative nature of this activity.

In addition, the outcomes of the formation of future computer science teachers' media competence will be manifested later in the professional activity.

Educational and pedagogical activities require a system of knowledge on the means and methods of resisting the manipulation of various media resources, patterns of behavior which are necessary for the successful pedagogical activity, especially for computer science teachers, because their work is inextricably linked to modern information technology. Thus, among the criteria for the formation of future computer science teachers' media competence, we should mention action-related and interpretative-creative criteria – a system of knowledge on the ways and means of resisting media manipulation, application of critical thinking skills when working with information of various types and selection of a system of necessary actions. The criteria of effectiveness include indicators that reflect the objective side of the activity outcomes and the subjective attitude of students to this activity. The system of criteria should be unified, i.e. all indicators included in it in terms of content and mathematical expression, should not oppose each other (Friedman, 1999).

Successful implementation of various activities requires the orientation of the personality for the value-oriented attitude, interest, awareness of personal and social significance. As a result, the next criterion for the formation of future computer science teachers' media competence is a motivational one.

Cognitive criterion combines a system of knowledge on the features of the media and reflects the theoretical side of students' learning; ability to identify the causes and patterns, which will increase the efficiency of the educational process; ability to reveal contradictions that give rise to the research problem; ability to get innovative experience in order to find ways and means to increase the efficiency of the educational process; ability to observe, analyze and generalize; awareness of professional self-development and personal self-improvement which include professionally important qualities; ability to perceive the media, which the level of formation of media competence depends on; ability to find, use, deliver, and put into practice the theoretical and practical knowledge.

Friedman (Friedman, 1998) notes that "any mental activity should have these three components (in particular, need-motivational, operational-active, reflexive-evaluative), and the most important task of education is to teach students to organize their own activity as a full-fledged, mental, in which all three components are balanced, sufficiently developed, realized and fully implemented".

In order to identify the criteria for assessing the effectiveness of students' learning, we consider it necessary to take into account the main areas of personality, namely: needs-motivational, operational and criterial-evaluative. Let's try to give a brief description of the selected areas.

The needs-motivational sphere of personality is an integral quality characterized by a set of social guidelines; value orientations, interests that form the basis of motives.

The operational sphere of the individual's activity is an integral quality characterized by a set of common and special knowledge, skills and abilities.

The next criterion that helps to identify the outcomes and analyze your own activity is a reflexive one. It is necessarily included into human activity and is aimed at understanding your own actions and deeds. Reflection-based self-analysis and self-assessment provide control, ability for self-cognition, ability to analyze your own actions, deeds, motives, correction and self-improvement; it actively cultivates the individuality and creative potential (Skripnichenko, 1989).

Thus, on the basis of the analyzed scientific and pedagogical literature and in accordance with the specifics of pedagogical activity of computer science teachers, we have identified the following criteria for the formation of future computer science teachers' media competence (figure 1): motivational; interpretative-creative; cognitive; action-related; reflexive.

It is possible to speak about the process of formation of future computer science teachers' media competence on the basis of comparison of indicators and levels of media educational abilities and skills received at the initial and final stages of the experiment.

The classification of indicators of personality's media competence has been designed by us (figure 2). When developing the classification of the formation of future computer science teachers' media competence, we also took into account the characteristics of high and low levels, presented in (Potter, 2018).

Characteristics of a high level of media competence formation (Potter, 2018): ability to get the main meaning of the media text; analysis: identification of the main elements of the media text; comparison: identification of similar and unique fragments of media text; assessment of the value of the media text or its fragment; judgments based on the comparison against certain criterion; abstracting: ability to provide a short, clear and accurate description of the media text; generalization; deduction: use of general principles to explain certain information; induction: derivation of general principles based on the observation of single pieces of information; synthesis: ability

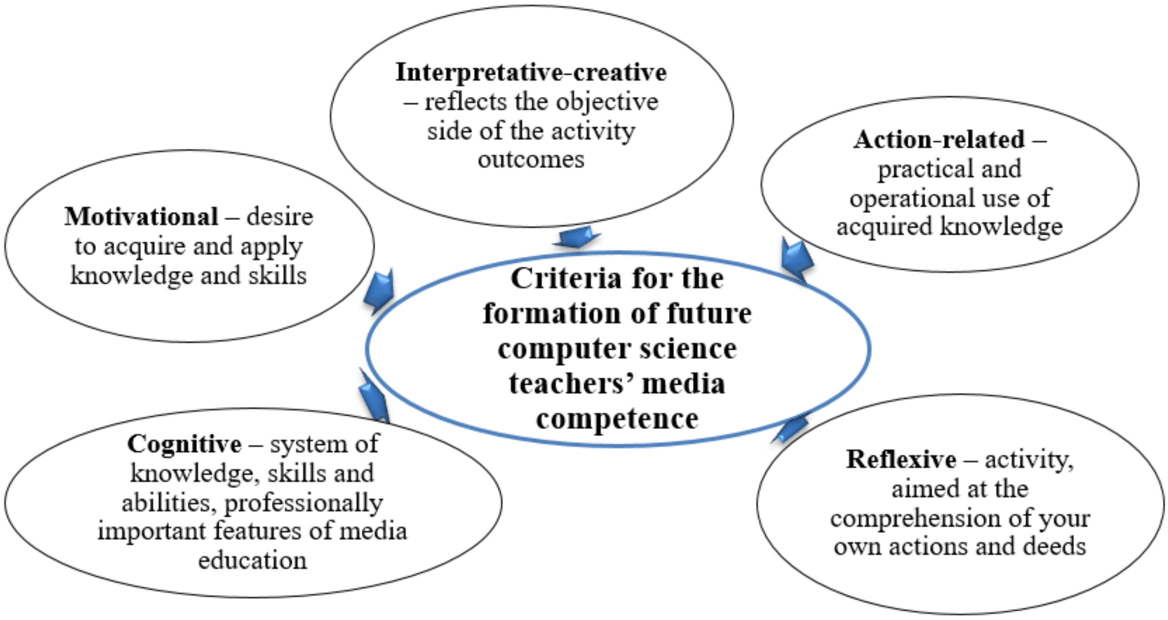

Figure 1: Criteria for the formation of future computer science teachers' media competence.

to reassemble elements into a new structure.

Characteristics of a low level of media competence development (Potter, 2018): low level of intelligence (in terms of problem solving and creativity), feeling that "everything goes in its turn"; weak memory when a person sometimes is able to remember only very important things (for example, the night before the exam); thematic dependence, lack of insight, i.e. lack of understanding of what is important in the messages; need for a mentor, assistant, handbook, or guide while studying; low level of tolerance to the ambiguity of media texts, uncertainty; weak conceptual differentiation when having a few categories of messages; negative attitude to new messages that do not correspond to the usual categories, or simplification of this media text – transferring it to the easiest category; high impulsiveness of quickly made decisions with sacrifice of accuracy.

Let's find out what indicators characterize each of the selected criteria (figure 2):

- Indicators of the motivational criterion are: a high level of motivation to learn and awareness of positive motivation lead to the active use of methods of critical analysis in professional activity; need to master media competence and understand its role in achieving professional success; motivation to develop skills that allow you to operate with any information freely and correctly (receive, analyze, synthesize), cognitive need; formation and manifestation of personal qualities (persistence, purposefulness, endurance, self-control, emotionality) and professionally important qualities (constructive (ability to set the goal and objectives of the educational process taking into account current trends in media development and dissemination; ability to identify such forms and methods of educational work that will help to achieve the goal), cognitive (desire to be engaged in continuous professional development and self-improvement, analysis of pedagogical experience, wish to expand the range of your own knowledge, ability to freely navigate in the content of the educational process).
- Indicators of the cognitive criterion are: the amount of knowledge acquired, ability to identify the causes and patterns, which will increase the efficiency of the educational process using media technology; awareness of acquired knowledge; ability to reveal contradictions and resist various manipulations and as a result to create a research problem; ability to predict the outcomes of learning and plan the activities of students, which will contribute to the achievement of the outcomes; ability to study and analyze the activities of media educators, different types and genres of media texts, in order to find ways and means to increase the effectiveness of the educational process.
- Indicators of the interpretative-creative criterion are: the ability to apply a critical analysis of the media and various media texts functioning in the society; ability to apply existing knowledge in the context of any particular media text; ability to

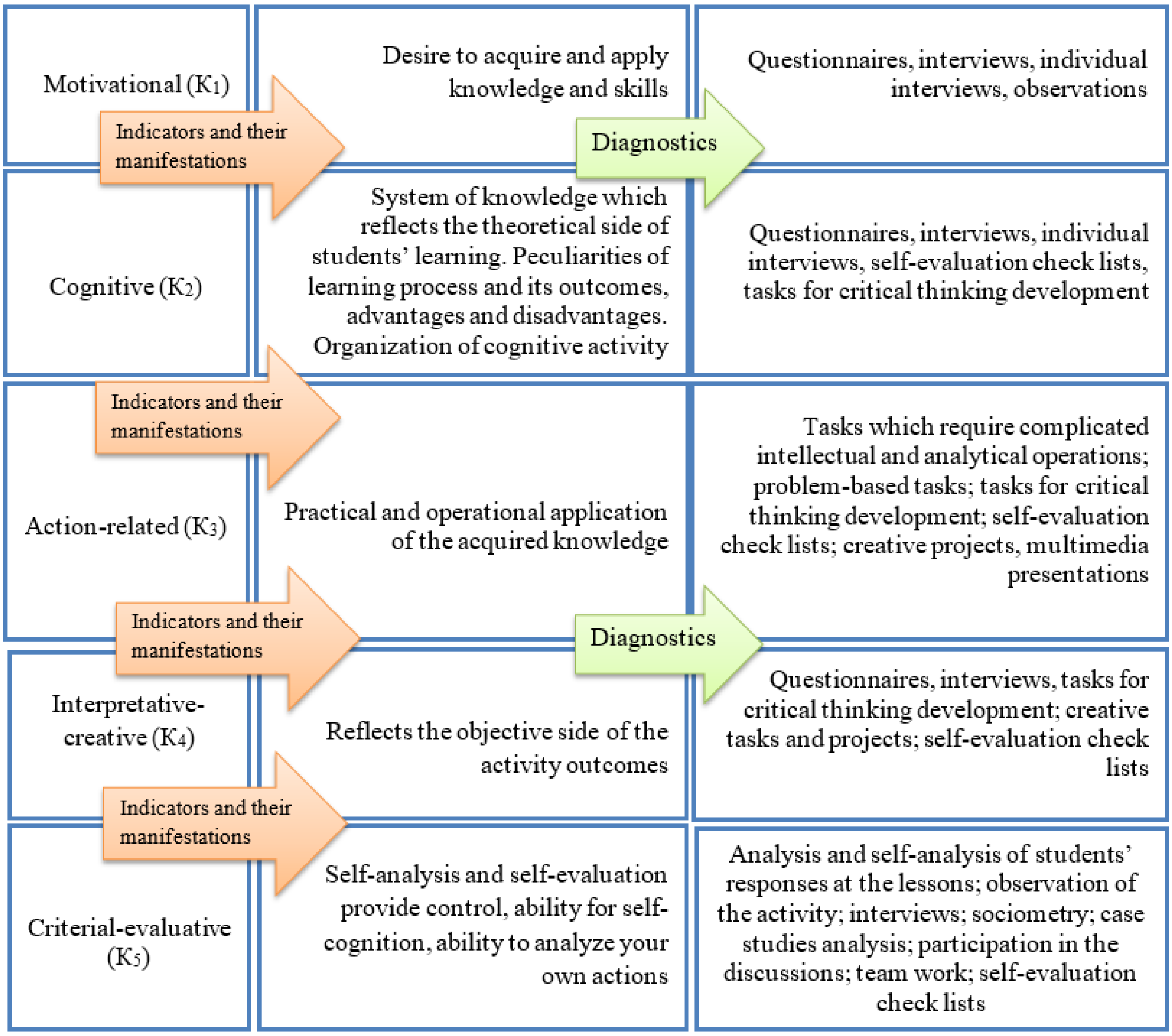

Figure 2: The system of criteria for the formation of future computer science teachers' media competence.

draw parallels during critical analysis; development of creative potential in various aspects of activities related to the media (gaming, art, research, etc.).

- The indicators of the action-related criterion are: the level of mastering a set of actions that allow you to critically analyze existing media, distribute and design your own media texts; ability to put the acquired knowledge into practice; desire for self-education in the field of media.
- Indicators of the criterial-evaluative criterion are: the ability to identify the effectiveness of the media product and feasibility of its use; ability to subjectively evaluate the results of your own activities; ability to assess the compliance of used pedagogical technologies (technologies for critical thinking development, information technology, distance learning technology, etc.) to modern requirements.

Levels of effectiveness of learning can be theoretically substantiated according to a five-point scale: negative (very low), passive (low), moderately active (satisfactory), active-productive (high) and creative (very high). But in fact it is possible to limit it to a three-point scale of a level of formation of future computer science teachers' media competence: low (conditionally marked as I); medium (II) and high (III).

Taking into account the conclusions of scientists, developed criteria and qualitative characteristics of future computer science teachers' media competence according to three levels (high, medium, low), we have developed the characteristics of each level.

K1 – motivational criterion.

- The high level of the motivational criterion formation is characterized by future teachers' increased interest in the use of media technologies in teaching computer science lessons; high activity and independence in pedagogical activity, orientation for creativity, predominant analytical activity, experience of positive emotions while participating in educational process; predominance of internal motives over the external ones.
- The following features are typical for the medium level: teachers demonstrate an occasional interest in the use of media technologies in teaching computer science lessons; motives do not correspond to individual possibilities and desires, episodic instructions for creative activity; lack of positive emotions in the process of pedagogical activity.
- The following indicators are typical for the low level: future teachers have a lack of formed intentions; values that do not reflect the objective content of the work are predominant ones; utilitarian motivation to master media technologies prevails; teachers demonstrate vagueness of interests and inclinations.

K2 – cognitive criterion.

- The high level of cognitive criterion is characterized by the following: awareness of basic terms, theories, basic facts of the media education history, creativity of media figures, a clear understanding of the process of mass communication and media impact in the real world context; compliance of the content of basic professional training with the current state and prospects of subject area development and interaction with the media; design of individual learning trajectories by students (Spirin, 2010).
- The following features are characteristic for the medium level: awareness of some basic terms, theories, some facts of the media development history, mass communication, media impact, creativity of individual media figures.
- The following indicators are typical for the low level: lack of awareness (or minimal knowledge in this area) of basic terms, theories, facts of the history of media development, mass communication, media impact, creativity of media figures.

K3 – action-related criterion.

- Future computer science teachers with a high level of the action-related criterion development clearly demonstrate the need to realize their abilities in the educational process; they have a high degree of critical analysis; the purpose and tasks of the classes are characterized by creative approach; such teachers use action-related approach in teaching computer science, their teaching is characterized by the predominance of active teaching methods; they have practical skills of independent choice, design and distribution of media texts of different types and genres, practice active self-education in the media sphere.
- The future computer science teachers with a medium level of action-related criterion have an unclear need to apply the abilities and acquired knowledge in the educational process; activity in mastering important knowledge and skills is not enough demonstrated; such teachers are able to select and design media texts of different types and genres only with the help of expert consultations.
- Future computer science teachers with a low level of this criterion rarely use any methods to intensify their work; their practical skills of selection and design of media texts, skills of self-education in the media sphere are not well developed or they demonstrate unwillingness to develop them.

K4 – interpretative-creative criterion.

- The teachers with a high level of formation of interpretative-creative criterion are characterized by: the ability to apply critical thinking technologies taking into account various factors in the analysis of various media texts and media sources; ability to analyze, synthesize and design their own media texts taking into account the aspects of space and time; they are able to abstract the material, make comparisons and make their own critical assessment of the media of any complexity.
- The medium level of the interpretative-creative criterion formation is characterized by the following features: the ability to apply technologies of critical analysis of the media, taking into account key factors based on the average development of critical thinking.
- The following indicators are characteristic for the low level of formation of the interpretative-creative criterion: tendency to

external influence, lack of skills and abilities of critical analysis, lack of critical thinking skills.

K5 – criterial-evaluative criterion.

- Students, future computer science teachers with a high level can freely operate their abilities and use them properly in their professional activities; they are capable of self-assessment and self-criticism; they are able to correlate requirements with their personal features, carry out self-diagnostics and are ready for self-development.
- Students with a medium level of formation of the criterial-evaluative criterion are characterized by the following indicators: the average level of orientation in their own abilities, their self-esteem is not always stable but adequate.
- Students, future computer science teachers with a low level of formation of the criterial-evaluative criterion have a low level of orientation in their own abilities; their self-esteem is low, they do not use methods of self-diagnosis; they tend to minimize their own capabilities, do not believe in themselves.

Therefore, media competence is a set of motives, abilities, knowledge and skills (indicators: motivational, cognitive, action-related, interpretative-creative, criterial-evaluative) that promotes selection, critical analysis, design, evaluation and dissemination of various media texts and complex processes of media functioning.

Along with the significant positive experience of introducing media education in Ukraine at the current stage, there are also significant problems. First of all, it is insufficient methodological support of media education in secondary schools – for instance, if there is a curriculum and a textbook for higher education, this issue still remains unsolved for secondary school. This problem becomes even more relevant if we take into account that the most effective way to develop media skills is to integrate them into existing subjects and courses, which obviously requires adjustment of relevant syllabi, teaching aids and methodological materials, additional teacher training. There are also more general problems on the way to the development of modern media education in Ukraine. This is the inertia of the education system, which inherited from the Soviet era the insufficient attention to the development of critical thinking, especially while doing the social science courses. At the same time, first successful steps in terms of introduction of media education in Ukraine, as well as active participation of scientists and representatives of the professional community in this process, give grounds to expect further successful development of media education in our country.

3 CONCLUSIONS

Nowadays, the learning process is a work with a large number of information sources, which are difficult to understand without the ability to work with media information. It is widely accepted around the world that educational institutions should teach students to have a critical attitude to the information provided by the media. One of the ways to involve students in the full understanding of media information is media education – education by means and based on the materials of various media sources. Media education opens great opportunities for the children's development, their intellectual and creative potential, abilities, critical thinking.

Moreover, media education opens up many new opportunities for teachers in terms of use of creative approach in the organization of the educational process.

The media revolution is just beginning. To help our children navigate the world of media, we need to become media literate ourselves. But we do not have time to master media literacy. Therefore, it is very important to do it together with children, to get to know media together, to "read" and critically comprehend media texts together, to create your own media products together. To achieve this goal it is important to qualitatively train a computer science teacher.

The media education of the future computer science teacher can be considered as a resource that can increase the effectiveness of teaching students of secondary schools. Therefore, the future computer science teacher should teach secondary school students to work with the latest information resources, and most importantly prepare them for the integration into the global information space. It should be noted that readiness for professional activity consists of indicators of pedagogical readiness and media competence. Therefore, to assess the effectiveness of the formation of future computer science teachers' media competence, the following criteria have been developed: K1 – motivational (the desire to master and apply knowledge and skills); K2 – cognitive (system of knowledge that reflects the theoretical side of students' learning, features and outcomes of the educational process, advantages and disadvantages, organization of cognitive activity); K3 – action-related (practical and operational application of acquired knowledge); K4 – interpretative-creative (reflects the objective side of the activity outcomes); K5 – criterial-evaluative (self-analysis and self-assessment provide control, ability for self-cognition, ability to analyze their own actions). Each of the criteria is diagnosed separately, and based on the information obtained we can identify the level of media competence.

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Features of Implementation of Augmented and Virtual Reality Technologies in the Psycho-correctional Process of Development of Emotional Intelligence of High School Students in Terms of Professional Self-determination

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Keywords: Augmented Reality, Interactive Technologies, Emotional Intelligence, Visualization, Professional Self-identification, Professional Orientation, Empathy, Emotional Awareness, Self-Motivation, Emotional Stability.

Abstract: Trends of modern society development, boom of the computer technologies, globalization and informatization affect all areas of public life, including education. In the conditions of transformational and epidemiological changes the significance, aim and mission of modern education include not just gaining basic knowledge and necessary skills and abilities but also the development of a cultural code, an independent approach to acquiring new knowledge, cultural values, and new forms of the activity. Currently, to solve this problem, innovative methods are used; these methods contribute to more effective acquisition of new knowledge with a high degree of students' involvement in the educational process. These methods also include augmented and virtual reality technologies, i.e. they can be both a learning tool and the research objectives. The paper presents a practice-oriented model of introducing the components of augmented and virtual reality in the process of developing the high school students' emotional intelligence at the stage of their professional self-identification as a key factor of the development of professional self-awareness. An empirical study of high school students' emotional intelligence, based on the elements of augmented and virtual reality, which was carried out before piloting the program showed the following results – the majority of students are dominated by a low level of emotional intelligence. The least pronounced is the ability to manage both their own emotional state and the emotions of other people. In particular, we have to emphasize a tendency of high school students of social type of professional self-identification to recognize the emotions of other people. Participants with a realistic type of professional self-identification have a low level of empathy; those having the entrepreneurial type of professional self-identification have low scores on the scale of emotional management. As a result of approbation of the components of augmented and virtual reality, it was found out that the level of intrapersonal emotional intelligence significantly increased among the respondents with a social orientation of professional self-identification. The priority task of designing a comprehensive program for the introduction of augmented reality in the modern educational space is to increase ergonomics, safety of the use of augmented and virtual reality elements in the process of development of high school students' key life competencies.

1 INTRODUCTION

The need for innovative changes in the modern educational system is determined by the fact that in today's informational society, the main conditions for the well-being of everyone are the knowledge, gained through unhindered access to information, and the ability to work with it. In today's world, advanced technologies, which include information and communication technologies and augmented reality technologies play a key role in the economic development of society, providing new incentives to increase the

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competitiveness of the individual. Recently, there has been a rapid development of augmented reality technologies (Kramarenko et al., 2020). According to Zijadic et al. (Zijadic et al., 2020), the market for applications, using elements of augmented and virtual reality, will expand annually, in particular, due to the emergence of new areas of their use, including the sphere of education. Recent studies of show that the market for educational software in 2019 was $ 9.9 billion (Liu, 2020). Forecasts suggest that the education software market will amass worldwide revenues of around 10.4 billion U.S. dollars in 2021. Should this forecast hold, it would represent a year-on-year growth of over 200 million dollars. Estimates suggest that this trend of strong growth will continue for years to come, reaching 11.3 billion dollars by 2024 (Liu, 2020). This indicates the active implementation and use of software in all areas of education. Social changes that take place in society at the level of global processes are more evident than the processes that occur in the mind, psyche, and inner state of the individual.

One of the main tasks of education in secondary school is the development of creative thinking of the individual, who is able to adapt to the conditions of new life and responsible for self-education, self-control and self-improvement (Vlasenko et al., 2020). However, the process of choosing a life and professional path becomes very difficult for today's youth, who are not ready to respond properly to the surrounding conditions, manage their emotions, assess their personal potential, and overcome the difficulties caused by changes in society. Emotional readiness for the professional activity is considered to be a conscious readiness of a specialist to apply the emotional competencies necessary for the constructive solution of professional tasks. In this regard, it is very important to study the impact of emotional intelligence on the professional self-identification, in particular the ability to understand, manage and control your own emotions depending on the situation. At the same time, the issue of identifying ways and methods of diagnosis and development of emotional intelligence as an integrative component of high school students' effective professional self-identification is quite complicated. The main problem is a constant change of the configuration and dominant means of information perception.

Modern teenagers are representatives of a new generation. These teenagers have got into the whirlpool of rapid technological development and social changes. A typical representative of this generation is a child who learns how to use YouTube before he or she learns to read and write. The best leisure activities for these children are surfing the Internet, social networking and watching videos. At the same time, parents and education in general face a new difficult task – to find something that will motivate, inspire and reveal the talent of each individual. Representatives of new generation will no longer be able to imagine the world without virtual and augmented reality, smartphones, e-books, mobile devices. Accordingly, the methods of influencing and developing personal resources of the younger generation also require global changes, taking into account trends in science, technology and information capabilities of the modern educational environment. Taking into account the high school students' individual and age psychological characteristics, the priority of the research is an introduction of innovative augmented reality technologies into the development of younger generation's emotional intelligence.

2 LITERATURE REVIEW

Modern scientific research is focused on the combination of innovative technologies in science and technology, taking into account the personality's individual typological characteristics. Emotional readiness for professional activity is considered to be a conscious readiness of a specialist to apply emotional competencies necessary for the constructive solution of professional tasks. In this regard, the study of the impact of emotional intelligence on professional self-identification, in particular the ability to understand, manage and control their emotions depending on the situation becomes more and more relevant. Modern scientists consider emotional intelligence to be one of the factors of the ability for professional self-identification. The level of emotional intelligence development will determine to what extent a person is able to adapt to the chosen profession, achieve certain outcomes and realize their own professional and personal potential. Scientists pay considerable attention to the analysis of the relationship between the emotional sphere of an individual and his or her psychological well-being and health, ability to maintain stability and prevent personal and professional burnout (Grover and Furnham, 2021). Scientists have found out that the sufficient level of the emotional intelligence development acts as a buffer in the manifestation of the negative effects of stress. It helps to stabilize the emotional state and prevent mental disorders such as psychopathy. Dave et al. (Dave et al., 2019) in the longitudinal study empirically established the relationship between emotional intelligence and motivation to continue learning after school, i.e. to get higher education. According to the (Dave et al., 2019), emotional intelligence is, first of all, a complex combination of emotional self-perception and personal trends associated with the perception, understanding, use and management of their own emotions and emotional states of other people.

Scientists assign a significant role to the emotional intelligence as a factor which increases the personality's motivational component. In the empirical study, lin Tam et al. (lin Tam et al., 2021) prove a correlation between the level of emotional intelligence development, increased motivation and improved academic performance. Scientists also confirm the interdependence of the level of emotional intelligence development and academic achievements with the behavioral and emotional component of professional development. The results of the empirical research showed that emotional intelligence had a significant direct impact on the behavioral and emotional involvement in the process of learning (Thomas and Allen, 2021). Thus, this empirical and practical research allows us to conclude that functional characteristics of emotional intelligence are represented by a system of emotional attitudes to themselves as the knowers, to the world and other people, and these features are reflected in social interaction. Emotional intelligence should be considered in the context of the category of "activity", because it is developing and is manifested in the activities, in the process of communication and interaction with other people. Therefore, emotional intelligence is an important integrative component of the process of successful career guidance.

Increased interest in the research and development of emotional intelligence has allowed us to expand the idea of traditional tools and take into account trends in the development and implementation of innovative ICT not only in the educational process but also in modern psychological practice. Accordingly, in order to optimize the process of studying the level of emotional intelligence of children, Narimani et al. (Narimani et al., 2019) suggest to use MSCEIT (Mayer Salovey Caruso Emotional Intelligence Test) – one of assessment tools, which uses the approach to the evaluation of the effectiveness of the emotional intelligence realization. To make the evaluation process more exciting and interesting for the children, the researchers gamified the whole process. Researchers have developed and implemented a mini-game, the main task of which is to measure the emotional intelligence of children, focusing on the game participants and facilitation tasks, which are presented in MSCEIT. The emotional component, as an important constant of social interaction, has made it possible to update research related to the introduction of the emotional component in various artificial intelligence systems. Thus, researchers have found out that the emotional coefficient is still absent in the current generation of interactive chat bots. According to the scientists, it leads to a decrease in the quality of communicative and social interaction, and can also lead to the emotional rigidity of users. Accordingly, the study describes the stages of development of a block of such agents, i.e. the ability to respond with a certain emotion to the input text, which contains a certain emotion and improves the process of understanding the information environment (Shankar et al., 2021). Other studies are devoted to the multimodal recognition of emotions in the process of developing the emotional intelligence of users (Shah et al., 2021). Because of the fact that people express emotions not only in speech, but also by the voice tone and facial expressions, the developers used the functions of three modes – text, audio and video, and tested different fusion techniques to combine models. Shah et al. (Shah et al., 2021) proposed a new architecture specifically designed for dyadic conversation, where each person is modeled using a separate network that shares an emotional context. Researchers also analyze the degree of students' emotional intelligence development depending on the perception of emotions displayed by virtual instructors. Lawson et al. (Lawson et al., 2021) found out that students were able to distinguish positive emotions from negative ones; they considered the teaching of positive instructors to be more effective, more reliable, more human and attractive. In addition, students who saw positive emotional reactions from virtual instructors, indicated that they tried to pay attention to the lesson and enjoyed it more than those who saw negative emotions displayed by virtual instructors.

Having analyzed the priority of using modern ICT in the process of professional self-identification and personality development, we consider the study (Tkachuk et al., 2021), aimed at the identification of the effectiveness of the methods of audience response systems and mobile tools for practical training in the university, to be an innovative one. Researchers have analyzed Ukrainian and foreign research works on the use of mobile ICT in education. The authors have developed methods for applying audience response systems using Plickers and mobile tools for multimedia development based on augmented reality tools. Scientists' comparative assessment of the functionality of audience response systems and mobile tools for the development of multimedia based on augmented reality provides an opportunity to state the effectiveness of the use of appropriate augmented reality technologies in the process of optimization and individualization of academic learning (Tkachuk et al., 2020). In the context of individualization of the professional and personal development taking into account the individual psychological characteristics of students, it is important to study the implementation of a conceptual model of learning based on the combination of AR and VR technologies with adaptive learning systems. The authors substantiate the use of VR and AR technologies as a special information environment, which is used in accordance with the identified dominant types of thinking and intellectual abilities of students (Osadchyi et al., 2020). In Europe and the USA, the use of AR and VR technologies is actively carried out in psychotherapeutic practice, in psychological counseling and psychocorrection. In particular, in 2008 in Brussels (Belgium) the International Association for Cybertherapy and Rehabilitation was created, which publishes its own journal – CyberTherapy & Rehabilitation. Members of this association contribute to the creation, implementation and promotion of new AR and VR technologies in clinical practice. AR and VR methods in psychotherapy are considered as complementary to traditional. Taking into account the increased interest and achievements of scientists and practitioners in the field of use of augmented reality systems and applications for the optimization of cognitive processes, intelligence, emotional and volitional sphere of personality, the issue of analyzing the development of emotional intelligence using modern ICT and design of a comprehensive program of traditional psychotechnologies and augmented reality technologies in the process of developing the high school students' emotional intelligence at the stage of their professional self-identification is becoming a relevant one.

3 RESEARCH METHODS

Interdisciplinary research was conducted as part of the research work carried out at the expense of the general fund of the state budget: "Adaptive system for individualization and personalization of future professionals' training in the conditions of blended learning", state registration number: 0120U101970. A comprehensive interdisciplinary study was conducted in the framework of scientific cooperation between STEAM-laboratory, Laboratory of Psychophysiological Research and Laboratory of Health Psychology of Bogdan Khmelnitsky Melitopol State Pedagogical University. Methods used in the research process are: analysis of theoretical sources, study of advanced psychological and pedagogical experience of foreign and domestic teachers on the implementation of competence-based and personality-oriented approach in the educational process, development of emotional intelligence of future students at the stage of professional self-identification; methods of generalization and conceptualization to formulate the main provisions of the study; design and modeling of an empirical construct of a combination of traditional and innovative AR/VR technologies in the diagnostics and development of high school students' emotional intelligence; generalization and evaluation of results.

4 RESEARCH RESULTS

Theoretical and empirical study of the development of components of high school students' emotional intelligence at the stage of their professional self-identification based on the elements of augmented reality was conducted on the basis of Bogdan Khmelnitsky Melitopol State Pedagogical University from 2019 to 2020. The piloting study was attended by high school students from Melitopol (educational establishment No 16, secondary school No 7, 14), future university entrants. Participation in the study was voluntary, conducted with the consent of parents or guardians. The sample is representative. The total number of participants was 93 people (girls and boys) aged 15 to 17 years. The study was conducted in several stages:

1. Analysis of the theoretical and methodological foundations of the process of emotional intelligence development in the scientific literature.
2. Construction of a structural-logical model of development of components of high school students' emotional intelligence at the stage of their professional self-identification with the use of augmented reality technologies.
3. Development, planning and implementation of a diagnostic procedure for the identification of the degree of participants' emotional intelligence development using the latest computer system for psychophysiological testing – HC-psychotest (Varina and Shevchenko, 2020). Empirical research was carried out in several stages:
   - Organizational stage: the choice of diagnostic techniques, the formation of a group of experiment participants.
   - Research stage: the first stage of empirical research was aimed at the identification of the role of high school students' emotional intelligence and the level of their professional self-identification.

- Analytical stage: the second stage of empirical research which includes quantitative and qualitative analysis of the obtained data, correlation analysis.

4. Development and piloting of a comprehensive program for the high school students' emotional intelligence development.

In the context of the analysis of theoretical models of personality's emotional stability the structural components of this phenomenon have been analyzed. In scientific psychology the first model of emotional intelligence was constructed in 1990 by Mayer et al. (Mayer et al., 2016). Emotional intelligence meant "the ability to follow your own and others people's feelings and emotions, to distinguish them from each other and to use the information obtained to guide your actions and thinking" (Mayer et al., 2016).

Emotional intelligence was viewed as a complex construct that included the abilities of three types: the recognition and expression of feelings, the ability to regulate emotions, the ability to use emotional information in the mental process and life. Final version of the model of emotional intelligence by Mayer et al. (Mayer et al., 2016) is presented as a model of abilities, in which emotional intelligence is the ability to process information contained in emotions; to identify the meaning of emotions, the relationship between each other; to use emotional information for thinking and decision making. In the structure of emotional intelligence within the model of abilities there are four groups of abilities called "branches": identification (perception, recognition) of emotions, the role of emotions in solving problems, understanding and analysis of emotions, conscious emotion management. This model of emotional intelligence laid the foundations for the concept of emotional intelligence developed by Goleman (Goleman, 1998), who supplemented the existing model with personal abilities: enthusiasm, perseverance and social skills (Cherniss et al., 2006).

According to Di Fabio et al. (Di Fabio et al., 2012), emotional intelligence is a set of all non-cognitive abilities, knowledge and competencies that give an individual the opportunity to successfully overcome various life situations. Di Fabio et al. (Di Fabio et al., 2012) identified five areas of competence. These areas are identical to five components of emotional intelligence. Each component contains subcomponents:

1. The process of self-knowledge: awareness of your own emotions, confidence, respect for yourself, wish for independence and self-actualization.
2. Developed interpersonal communicative skills: empathy, interpersonal relationships, social responsibility.
3. Ability for the adaptation: to solve problems, be flexible and to keep in touch with the real world.
4. Ability to manage a stressful situation: to be resistant to stress, to control impulsivity.
5. Predominant mood: happiness, optimism.

Analysis of the scientific literature allows us to identify the components of emotional intelligence are: self-awareness (awareness of their social status and their vital needs), self-control (awareness and evaluation of the subject of their actions, mental processes and states), empathy (understanding of emotional state, penetration - compassion in the experience of another person), relationship skills (actions that are formed by repetition, which are characterized by a high level of assimilation), motivation (motivations that cause activity of the body and the individual as a whole and determine its direction).

The main aspects of professional self-determination:

1. Professional self-determination is the selective attitude of an individual to the world of professions in general and to a specific chosen profession.
2. The core of professional self-determination is a conscious choice of profession, taking into account its features and capabilities, the requirements of professional activity and socio-economic conditions.
3. Professional self-determination is carried out throughout the professional life: the individual constantly reflects, rethinks his professional life and asserts himself in the profession.
4. Actualization of professional self-determination of the individual is initiated by various events, such as graduation from secondary school, vocational school, advanced training, change of residence, certification, dismissal, etc.
5. Professional self-determination is an important characteristic of the socio-psychological maturity of the individual, his need for self-realization and self-actualization.

Based on the results of theoretical analysis, we have developed a personalized model of emotional intelligence development, taking into account students' individual typological features (figure 1). The model is based on the following principles: principle of theory and practice balance, humanization of education, subjectivity, professional orientation, individualization, choice of individual educational path, situational learning, educational reflection, systematic learning, fundamentality. The purpose of designing the model is, on the one hand, social order of the society: the need for competitive professionals, on the other hand, future professionals' need for effective personal and professional development.

Criteria for the effectiveness of the developed model is its compliance with the stated goals and objectives, as well as recorded changes that occur with participants in the process, namely the positive dynamics of emotional intelligence and its components in high school students; development of empathy, self-esteem, self-confidence; development and optimization of communication skills, which are reflected in communication and interpersonal skills; development of socio-psychological competence; ability to navigate in social situations, understand other people, choose and implement adequate forms of communication; willingness to understand and accept another person's behavior.

Taking into account the priority prospects for the use of innovative computer technology in psychodiagnostic practice, the analysis of the development the emotional stability components was conducted on the basis of the Laboratory of Psychophysiological Research and STEAM-laboratory. In the Laboratory of Psychophysiological Research, in order to address issues of professional selection and career guidance diagnostics, scientists used the following set of HC-psychotests. "Candidate" is an effective and easy-to-use tool for professional orientation and professional selection, which allows you to assess the level of the manifestation of professionally important psychophysiological qualities and professional competencies, as well as to predict the further development of the specialist and conduct in-depth professional psychodiagnostics. The study was conducted in a group mode, using the program of HC-psychotest. During the study, the same conditions that affect the test results were created: the content of the test material; complexity of questions; time allotted for answers. Indicators for the choice of methods were the following: their compliance with the criteria of reliability and validity, age characteristics of the participants, adequacy (Varina and Shevchenko, 2020). The following methods were used in the empirical study: theory of career choice (Holland, 1974), questionnaire of emotional intelligence "EMIN" (Lioussine, 2003), technique of emotional intelligence (Hall, 2007). To identify the level of relationship between emotional intelligence and professional self-identification, as well as tolerance for uncertainty, we used correlation analysis (Pearson's correlation coefficient), Mann-Whitney's statistical criterion.

Thus, according to table 1, we found out that most students tend to have a profession of social and artistic types. The social type of professions predominates among the students of the 11th grade. For the 10th grade students the artistic type of professional self-orientation is more characteristic. This indicates the lack of a clear choice of direction of further employment.

Table 1: Indicators of values in the sample according to J. Holland's technique.

Names of the scales	**General**	**10th grade**	**11th grade**
Realistic type	5.3478	5.0938	5.6842
Intellectual type	6.4130	6.5000	5.4737
Social type	8.0000	8.0312	9.1053
Conventional type	6.3478	6.6250	5.9474
Entrepreneurial type	7.8261	7.5938	8.0000
Artistic type	8.1304	8.5625	8.7368

Therefore, according to table 2, we provide a more detailed quantitative and qualitative analysis of the obtained indicators. On the scale of InterU (understanding of your own emotions), we received an average score of 24.12. This is the average rate for this scale (23–26). This score is also within a norm in all groups of respondents. On the scale of InterM (management of other people's emotions), we received an average score of 19.65, which is also an average indicator, within the norm (18–21). According to the scale of IntraU (understanding of your own emotions), we received an average score of 16.49 with the norm (17–21), which is slightly below the norm. Having analyzed this indicator in groups, we found out that in the 11th grade it is low. On the scale of IntraU (management of your own emotions), the average score on the sample is 12.59, which is also below the norm (from 13 to 15), this figure is low in all groups. It can be explained by the fact that high school students do not have the skills to control their emotions because of developmental stage corresponding to their age. According to the IntraE scale (control over expression), we obtained an average score of 10.34, which is within the norm (from 10 to 12), but in the 11th grade it is on the border between low and medium level (low level – 7–9, medium level – 10-12). The obtained data tell us about the low level of control over expression, which may be due to the age range of the respondents.

On the scale of InerEI (interpersonal EI), we obtained an average score on the sample of 43.60, which is a medium level (40–46), this indicator remains medium for all groups participating in the study. According to the scale of IntraEI (intrapersonal EI), we received an average score of 39.82 with a norm (39–47). In the 11th grade, this figure is 36.05, which is

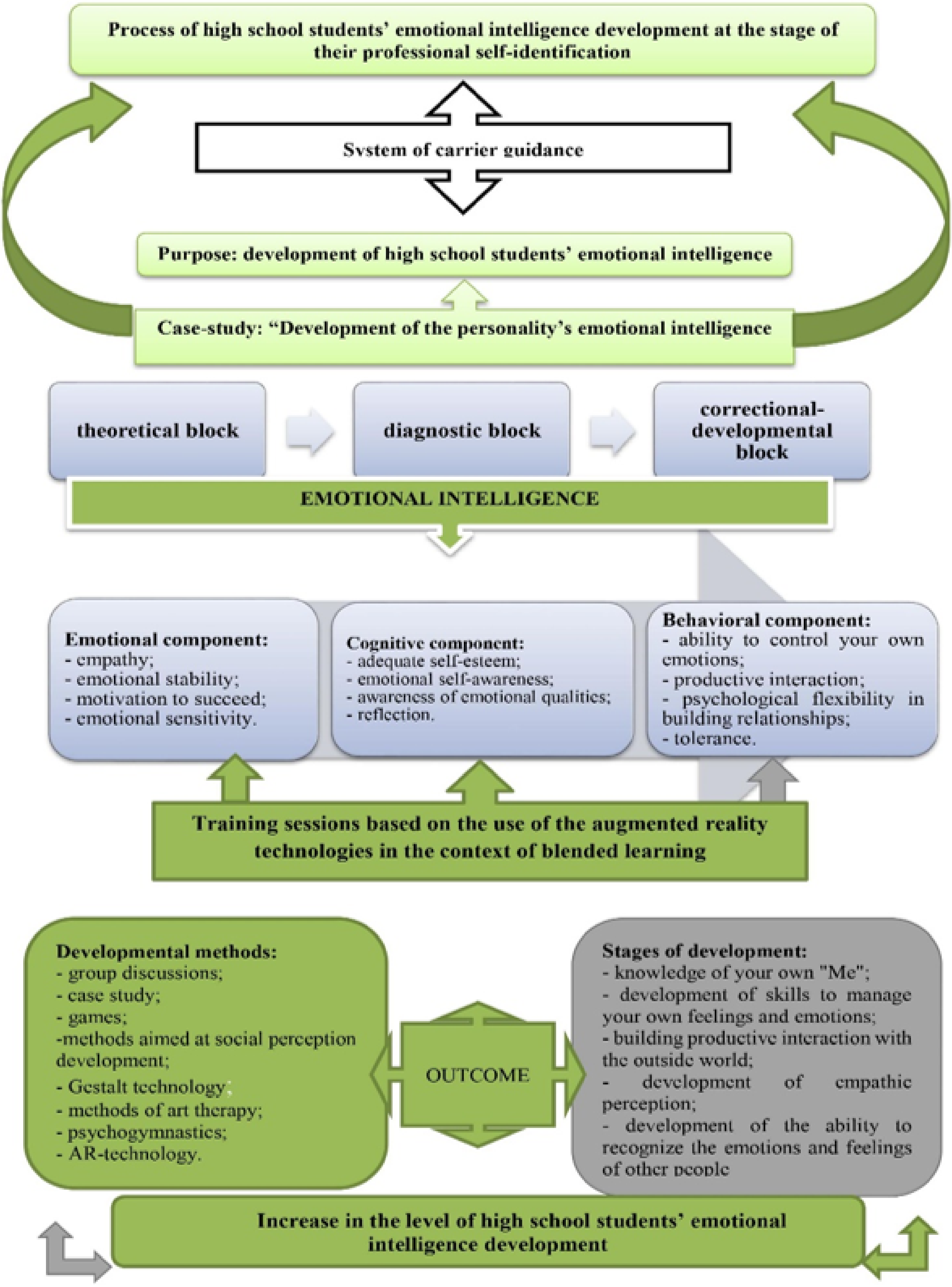


Figure 1: A comprehensive model of high school students' emotional intelligence development at the stage of their professional self-identification.

Table 2: Quantitative indicators according to the "EMIN" technique by D. V. Lusin.

Names of the scales	General	10th grade	11th grade
InterU (understanding of other people's emotions)	24.12	25.19	23.47
InterM (management of other people's emotions)	19.65	20.47	18.79
IntraU (understanding of your own emotions)	16.49	16.31	14.68
IntraM (management of your own emotions)	12.59	12.72	11.21
IntraE (control over expression)	10.34	10.72	9.11
IntraEI (interpersonal emotional intelligence)	43.60	45.50	41.68
IntraEI (interpersonal emotional intelligence)	39.82	40.38	36.05
UE (understanding of emotions)	40.33	41.31	37.63
ME (management of emotions)	43.11	44.56	40.63
General score	83.81	86.38	78.26

also below normal rate. According to the UE scale (understanding of emotions), the average score on the sample was 40.33, which is the medium result with the norm (40–47), in the 11th grade this figure is 37.63. On the scale of ME (management of emotions), the average result is 43.11, which is within the normal rate (40–47). The total general scale is 83.81, which is also within the normal rate (79–92). For a more detailed study of the levels of high school students' emotional intelligence, we used N. Hall's technique of emotional intelligence (table 3).

On the scale of managing your own emotions, the average figure is 0.44. It is low for the entire sample. It can be explained by the age characteristics of high school students. The self-motivation scale is also quite low. The general figure is medium – 6.3 (7 and below is considered to be a low level), it is slightly below the norm for each of the studied groups. On the scale of empathy, the average score is 7.59. It is on the border between medium and low levels. Having analyzed this indicator in detail, we see that in the 10th grade the score on the empathy scale is 9.84 and it is the normal rate. In the 11th grade, the score on the empathy scale is 7.68 and it is on the border between medium and low levels. The average score on the scale of recognition of other people's emotions is also on the border between medium and low levels, it is 7.09 points. In the 11th grade this indicator is low (6.63), but in the 10th – it is medium (8.59).

To prove the hypothesis that the participants with a high level of emotional intelligence will have a more detailed professional self-identification, which in most cases will be aimed at the professions of social type, we used the Pearson correlation coefficient. The calculation was done using the statistical software package SPSS 16.0. According to the obtained data, it was identified that on the scales of the social type of professional self-identification of recognizing other people's emotions the connection was established at the level of 0.01 (0.276). People with a social type of the profession understand well the emotional state of others because the fact how skillful the employee is depends of the understanding of other people's wishes. For further employment in the social sphere, you need to have a high level of ability to recognize the emotions of other people, and understand when and where they can be displayed. A slight positive shift of 0.05 (0.228) has been established between realistic type scales of professional self-identification and self-management. People of realistic type prefer professions where you need to be able to control your emotions. People with a realistic type of professional self-identification are usually emotionally stable, focused on today, reason rationally. As a result, the negative relationship of 0.01 (-0.278) between the realistic type of professional self-identification and empathy is expected. They do not need to understand other people's emotions. That is, people with a realistic type of professional self-identification rarely have a high level of empathy. Participants of entrepreneurial type of professional self-identification have demonstrated a significant negative relationship with the scale of self-management, it is at the level of 0.01 (-0.333). People of this type of professional self-identification are very active. They do not need to clearly control their emotions. The tendency of people of artistic type of professional self-identification to recognize other people's emotions has been confirmed, positive correlation, found at the level of 0.05 (0.259), indicates that people of artistic type understand the emotions of others very well. Also the respondents of the artistic type of professional-identification have a well developed intuition and imagination. Communicating with others people, they rely on their immediate feelings, which leads to a correlation of 0.05 (0.260) between the artistic type of professional self-identification and emotional awareness. Based on their own feelings, they easily understand the emotions of other people. They also develop empathy, understanding of other

Table 3: Quantitative indicators of the values in the sample according to N. Hall's technique.

Names of the scales	**General**	**10th grade**	**11th grade**
Emotional awareness	7.75	8.34	10
Management of your own emotions	0.44	0.84	-0.31
Self-motivation	6.3	6.78	6.84
Empathy	7.59	9.84	7.68
Recognition of other people's emotions	7.09	8.59	6.63

people's emotional states by facial expressions, gestures, posture, and tone of voice. This is confirmed by statistics, namely a slight correlation of 0.05 (0.273) between the empathy scales and the artistic type of professional self-identification was identified. When using Mann-Whitney statistical criterion in two groups with low and high emotional intelligence, it was found out that groups with a high level of emotional intelligence have a higher tendency to the intellectual type of professional self-identification. People of this type of profession constantly use their intellectual abilities. But talking about the conventional type, on the contrary, in the groups with a high emotional intelligence the tendency to choose the professions of this type is lower than in the groups with a low level of emotional intelligence. This is due to the fact that representatives of the conventional type of professional self-identification feel the lack of need to express emotions. But the entrepreneurial type of emotional intelligence development is almost not affected. Both groups with low and high levels of emotional intelligence can choose this area of professional self-identification. Participants who choose the artistic type of professional self-identification still have a fairly high level of emotional intelligence.

According to the results of the Mann-Whitney U-criterion, a statistical discrepancy was found out only in the social type of professional self-identification (table 4). We also revealed that people with a high level of emotional intelligence have a clearer focus on professional self-identification, while those with a low level of emotional intelligence choose several predominant professions. Accordingly, the dominant psychodiagnostic study established the dominant role of emotional intelligence in the process of conscious choice of future profession.

Based on the established relationships and concept of career guidance in the process of high school students' professional self-identification, on the basis of the Laboratory of Health Psychology and with the support of leading STEAM-laboratory specialists, researchers developed and piloted a comprehensive program "Development of high school students' emotional intelligence". Virtual and augmented reality is designed to provide a person's contact with information reality, as close as possible to ordinary reality (Rashevska and Soloviev, 2018), which contributes to the simultaneous integration of cognitive processes, motivational and emotional spheres of the individual. As a result of the implementation of augmented and virtual reality technologies, sensory-perceptual, visual, sensory parameters are preserved and even enhanced; the user here deals with superimages: three-dimensional, extremely distinct, which can be influenced, viewed from different angles. In a virtual situation, the developer retains and generates in relief only those properties of objects that are necessary for the implementation of the goals of the software product, in particular, the impact on the emotional component of intelligence.

The corresponding process of integration and impact of augmented and virtual reality technologies is presented in figure 2.

The 40 hour program is designed for blended learning. During September 2020, 4 hours of classroom work and 6 hours of interactive work in the Google Classroom system per week were carried out. Based on the model of emotional intelligence development (figure 1), structural psycho-correctional sessions have been developed, which include traditional psychological technologies and AR/VR technologies. Special technical equipment of STEAM-laboratory was used for realization of virtual and augmented reality constructs. There is a minimum set of equipment required to implement such an integrative approach: the required number of smart phones and VR helmets; tablet; mobile devices; computers; Wi-Fi router, Internet access; remote update system; instructional videos for interactive lectures and software; touch panel. The training program consists of 10 classes of 4 hours each (table 5). The augmented and virtual reality applications used in the presented program have both free and paid content. As part of the formative experiment, based on the implementation of the research project "Adaptive system for individualization and personalization of future professionals' training in the conditions of blended learning", as well as the expanded innovative material and technical base of the STEAM laboratory, a program for the development of emotional intelligence of high

Table 4: Differences in professional self-identification according to Mann-Whitney U-criterion between two groups with high and low levels of emotional intelligence.

	Realistic	Intellectual	Social	Conventional	Entrepreneurial	Artistic
Mann-Whitney U	394.5	369.5	306	369.5	418	398.5
Asymp. Sig. (2-tailed)	0.426	0.247	0.036*	0.243	0.654	0.462

* – connection is significant at the level of 0.05 and lower

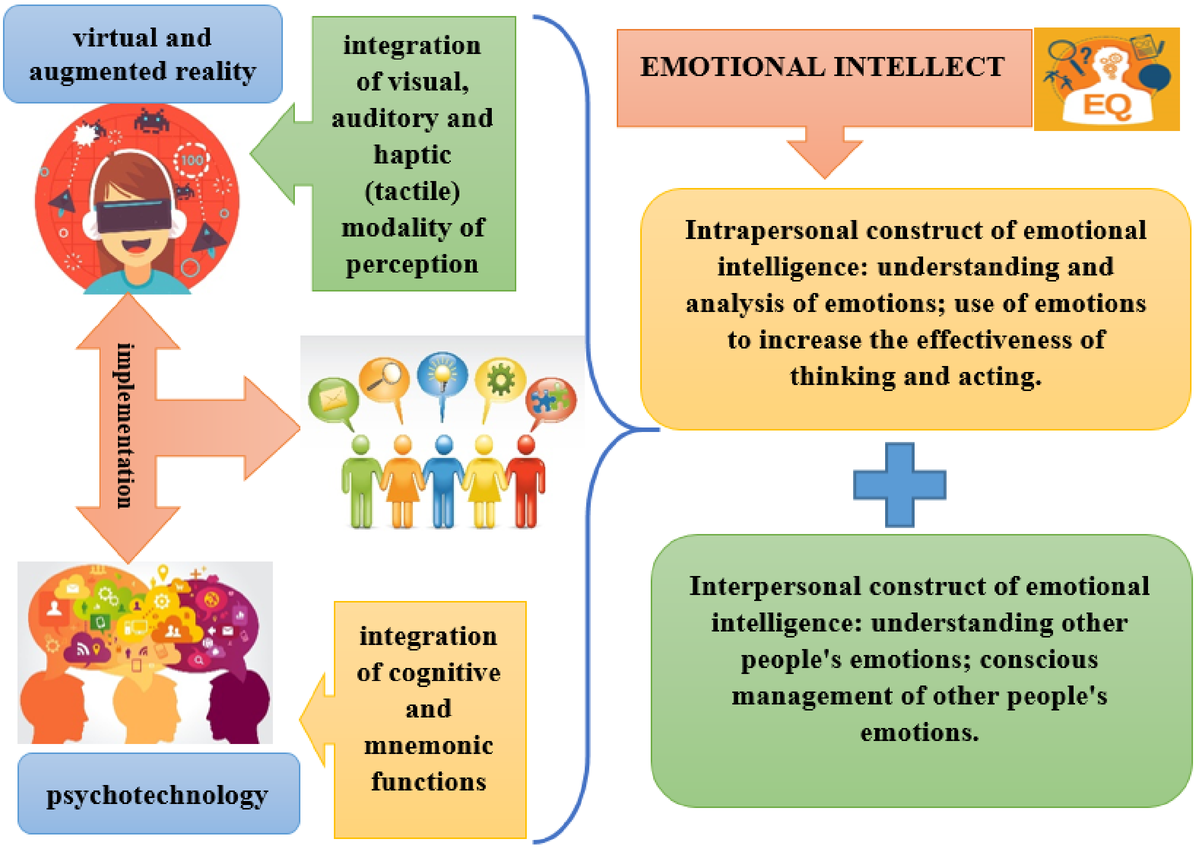


Figure 2: Scheme of implementation of augmented and virtual reality technologies in the context of the development of emotional intelligence of the individual.

school students was implemented in conditions of vocational guidance work. Our task was not so much to trace the complex impact of augmented and virtual reality technologies in conjunction with traditional psychotechnologies on the emotional state of an individual, but to determine whether they have an impact on the emotional component of intelligence. The corresponding comprehensive program was implemented in the experimental group from September to November 2020. 45 high school students took part in the training sessions.

The main mechanism for the implementation of augmented and virtual reality technologies in the psychocorrectional professor of the development of emotional intelligence is based on the mechanisms for reducing a certain emotional state situationally tied to specific objects and events embedded in individual applications. This approach is traditional and corresponds to European counterparts. This is the use of methods of cognitive and behavioral (behavioral) therapy, which among the majority of practicing psychologists are considered the most effective. The impact on the client's personal experiences was carried out through repeated repetition of emotionally colored situations with an avatar or object. In essence, this program implements systematic desensitization – a phased immersion of the client in a situation that causes a certain emotional state from the simplest to the most exciting image. The images were as close to real ones as possible, the subjects had access to high interactivity and animation. Virtual and augmented reality, created by visualizing three-dimensional objects using computer graphics, animation and programming methods, is a product of not only information, but also psychological technologies. Modern methods of constructing a time-varying virtual environment also make it possible to register the position of the observer in it, which opens up new research opportunities for experimental and applied psychology and equips it with methods that have a number of advantages over traditional laboratory instruments. The first of these benefits is environmental validity. With the help of augmented and virtual reality systems, it is possible to create not only unreal ("other") worlds, but also an environment "similar to the real world" and at the same time, which is especially important, to control all parameters of the experimental situation. The second is flexibility. The environment of augmented and virtual reality is programmable, which allows you to plastically change the parameters of objects and events occurring with them. It is possible to present a variety of variable stimuli (both stationary and moving) and accurately track the movements of the observer in virtual space. The third is the possibility of polymodal stimulation. Augmented and virtual reality systems allow simulating visual, tactile, auditory images at the same time, which is hardly achievable in traditional psychological research. Simultaneous influence on the sensory-perceptual system actualizes a number of sensations and emotional states. The fourth advantage is the ability to fully record the behavioral reactions of the observer.

According to the implemented BYOD concept ("Bring Your Own Device") when organizing classes using mobile learning technology, respondents can use their own gadgets with the necessary software installed (Feng et al., 2020; Doargajudhur and Dell, 2020). The introduction of elements of AR/VR technologies in the training process provides an opportunity to deeply influence the emotional world of the individual; it stimulates the ability to visualize and reproduce certain emotional states with augmented and virtual reality technologies; provides the possibility of close immersion in students 'own emotional world, its active knowledge and emotional development, self-regulation, stress resistance and the ability to understand the emotional world of another person (Vandana et al., 2020). Within the framework of psychological support of professional self-identification, the introduction of augmented and virtual reality technologies provides an opportunity for "real" immersion in a certain type of professional activity, "trying on" the profession in relation to students' own individual capabilities and preferences. Increase of the participants 'motivation and interest in individual and group work is also an important feature of the process of implementing AR/VR technologies in the psycho-correctional process. According to the results of the implementation of the training program using the elements of augmented and virtual reality, certain positive changes in the intrapersonal and interpersonal components of emotional intelligence of high school students were revealed. accordingly, positive changes are reflected in the overall index of emotional intelligence (figure 3 (a, b)).

The reliability of the results obtained on the change in the general level of emotional intelligence was tested using the criterion of signs G. Two hypotheses were formulated. H_0 – the shift towards changes in the level of emotional intelligence after applying a complex program using augmented and virtual reality technologies is accidental. H_1 – the shift towards changes in the level of emotional intelligence after applying a complex program using augmented and virtual reality technologies is not accidental.

Typical shift is positive (18), atypical – 4, $G_{emp} = 4$, $G_{crit} = 6$ (found using the table of critical values of the sign criterion), $G_{emp} < G_{crit}$, which means that the alternative hypothesis H_1 should be accepted, $p < 0.05$.

According to the results of the data presented in figure 3 shows the positive dynamics of the development of components and the overall index of emotional intelligence in high school students.

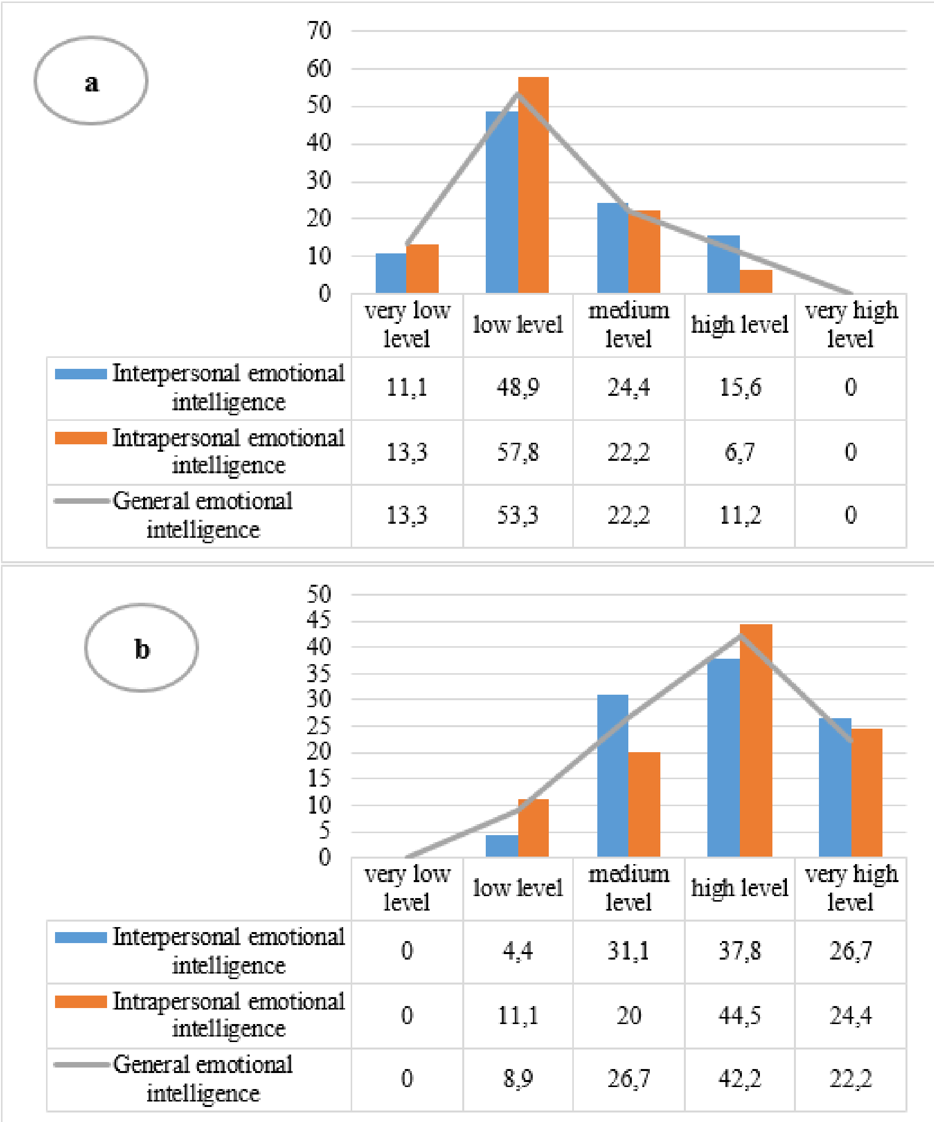
After the introduction of a comprehensive program with elements of augmented and virtual reality, there is a significant increase in the ability to understand their own and others' emotions and manage them in the respondents of the experimental group.

The ability to understand emotions means that respondents can effectively recognize emotional states, ie establish the very fact of the presence of emotional experience in themselves or in another person; can identify the emotion, or establish what kind of emotion is felt by a high school student or another person, and find a verbal expression for it; understand the reasons that caused this emotion and the consequences to which she will lead.

The ability to manage emotions means that respondents can control the intensity of emotions, especially to suppress excessively strong emotions; can control the external expression of emotions; can, if necessary, arbitrarily evoke one or another emotion.

Both the ability to understand and the ability to control emotions can be directed to both one's own emotions and the emotions of others.

Thus, we can talk about raising the level and dominance of high and medium level intrapersonal and interpersonal components of emotional intelligence. These two options involve the actualization of differ-



a	very low level	low level	medium level	high level	very high level
Interpersonal emotional intelligence	11,1	48,9	24,4	15,6	0
Intrapersonal emotional intelligence	13,3	57,8	22,2	6,7	0
General emotional intelligence	13,3	53,3	22,2	11,2	0

b	very low level	low level	medium level	high level	very high level
Interpersonal emotional intelligence	0	4,4	31,1	37,8	26,7
Intrapersonal emotional intelligence	0	11,1	20	44,5	24,4
General emotional intelligence	0	8,9	26,7	42,2	22,2

Figure 3: Dynamics of development of emotional intelligence of high school students of the experimental group ($n = 45$): a) the percentage of development of emotional intelligence of high school students to participate in a psycho-correctional program with elements of augmented and virtual reality; b) the percentage of the development of emotional intelligence of high school students after the formative influence.

ent cognitive processes and skills.

There was no significant quantitative difference in the indicators of emotional intelligence in the control group of respondents.

5 CONCLUSIONS

The use of augmented and virtual reality technologies provides high school students with new opportunities and prospects aimed at practice-oriented learning, promotes personal development and improve the quality of self-education, provides opportunities for the internalization of personal experience. In the context of professional self-determination provides an opportunity to bring high school students closer to real ideas about the future profession, to reduce the impact of social and psychological labels in the process of choosing future professional activities.

The use of reality technologies brings science to life, reproduces real life situations, helps to create fictional spaces for unsolved problems. It creates new opportunities for mastering practical skills, provides research experience, reveals the inner potential of the individual on the path to self-knowledge and self-development, makes activities a bright process, prevents distractions, increases motivation in decision-making, affects the emotional and cognitive sphere of personality, helps more to understand complex concepts, definitions, properties, which through emotional coloring are formed into a single plane of future professional activity.

Modern digital technologies based on VR/AR form the main criteria for professional selection, such as focus on the practical component of future activities, productivity, competitiveness, stress, increased concentration and attention, information retrieval, motivation, information competence and comprehensive assessment of academic achievement , improving the development of spatial, creative abilities and memory. The influence of augmented and virtual reality technologies on sensory channels promotes the activation of hemispherical interaction of the brain, which directly affects the emotional sphere.

Thus, emotional intelligence is a two-component construct, which consists of intrapersonal (ability to understand and manage your own emotions) and interpersonal (ability to understand and manage the emotions of other people) components. The role of emotional intelligence in professional self-identification is viewed as the ability to identify your own emotions and manage them in order to achieve the goal. According to the results of an empirical study of high school students' emotional intelligence indicators, it was found out that the majority of high school students have a low level of emotional intelligence. Analysis of the results of empirical research has shown that the least pronounced is respondents' ability to manage both their own emotional states and the emotions of other people. According to the results of the study, we found out that the participants with the social orientation of professional self-identification have a high level of interpersonal emotional intelligence. In particular, high school students of social type of professional self-identification are prone to recognize the emotions of other people. We also revealed that participants with a realistic type of professional self-identification have a low empathy level. Respondents with the entrepreneurial type of professional self-identification have low scores on the scale of managing their emotions. Based on the results of a diagnostic study, conducted in groups using the computer complex HC-psychotest, the training "Development of emotional stability" was developed and piloted. An innovative trend in the implementation of training is a comprehensive combination of traditional psycho-correctional and developmental technologies and AR/VR technologies.

The use of training and psychocorrectional programs of programs with components of augmented and virtual reality, specially aimed on personality changes, has a significant impact on the modification of functional personality structures (for example, emotional intelligence). Such programs can be used in the course of continuing education for adults. With their sufficient operationalization, the students themselves are able to reduce anxiety, reduce fears and negative emotions, stimulate positive emotional states by working individually and including self-regulation mechanisms. As a result of feedback from respondents, it turned out that the greatest impact on abilities is exerted, first of all, by didactic programs with elements of augmented and virtual reality, under the influence of which the formation of intellectual abilities is stimulated, as well as cognitive style through the actualization of positive emotional states. The implementation of traditional psychotechnologies and elements of virtual and augmented reality increase the level of reflexivity in cognitive activity and information processing. Correctional programs with components of augmented and virtual reality for the development of emotional intelligence in high school students contribute to a positive change in the conscious assessment of judgments about emotionally colored components of the situation, harmonization of the structure of the relationship between connotative and denotative meanings (meanings and meanings) within individual consciousness. The process of personality action in these programs also changes unconscious attitudes. Prospects for further research are the analysis of the impact of innovative technologies of augmented and virtual reality on the psychological characteristics of man in the educational space.

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APPENDIX

Table 5: Training program "Development of emotional intelligence" based on the use of AR/VR technologies.

Topic of the class	**Objectives**	**Psychological techniques and methods**	**AR and VR technologies**
1. Emotional competence as a vital resource	acquaintance with the training program; ground rules for group interaction; identification of participants' expectations; self-diagnosis of emotional intelligence; informing about the emotional sphere of a person; modeling the image of emotionally competent individual	brainstorming, art therapy, clustering, moderation, facilitation, role play, feedback	Graffiti Paint VR. Art Therapy. NeuroNation Ease: Mindfulness & Meditation
2. The world of feelings and emotions	"acquaintance" with the world of feelings and emotions; development of emotional self-awareness and competencies: observation of the flow of emotions, bodily sensations, thoughts; identification (recognition, naming), analysis of your own emotions, feelings; understanding of the reasons for their occurrence	brainstorming, art therapy, gestalt therapy, interactive mini-lecture, identification technique, case-study, technique of influencing the emotional state through changing body positions - "psychological sculpture", meditative exercises, self-training, technique of emotional introspection, music therapy.	VR Maze. VR Mission Leviathan. Moodpath - Depression & Anxiety Test. Wild Symphony. Coastiality
3. What can we do with emotions? Emotional self-regulation	responsibility for your own emotional reactions, self-controlled behavior and willingness to manage your own emotions in the steady and emotionally tense life situations; development of emotional self-regulation competencies: adjustment of intensity and evocation of desired emotions, restoration of emotional balance, resistance to immediate desires and emotions; verbalization of emotions and feelings; perception and understanding of nonverbal body language and movements; choice of authentic and adequate to the situation ways of emotional self-expression.	psychogymnastics, art therapy, emotional recharging technique, moderation, technique of metaphorical expression of feelings, technique of "Me-expression", technique of verbalization of partner's feelings, role play, "aquarium", technique of restoring emotional balance with the help of images, technique of separating "Me" from emotions, technique of working with emotions "7-P"	VR Thrills: Roller Coaster 360. VR Heights Phobia VR - Spider Phobia Horror. VR Relax Travel
4. Psychophysiological self-regulation of emotions	techniques and methods of psychophysiological self-regulation, release of muscle tension (breathing, muscle relaxation, meditation, etc.)	interactive mini-lecture, self-training, relaxation and visualization techniques, psychogymnastics, meditative breathing, physical exercises, technique of freeing unwanted emotions, self-suggestion techniques	Thisissand - Art, Creativity & Relaxation. Relax River VR.
5. Life position. Worldview and self-regulation	awareness of life values, beliefs about yourself and others; influence of life position on destiny; uniqueness of each person's picture of the world; development of tolerant attitude towards others	interactive mini-lecture, art therapy, facilitation, brainstorming, transformation game using metaphorical maps	NeuroNation – activities for brain, DEVAR – 4D augmented reality

Continued on next page

Table 5 – continued from previous page

Topic of the class	**Objectives**	**Psychological techniques and methods**	**AR and VR technologies**
6. Positive thinking. Intellectual self-regulation	awareness of the relationship between emotional competence, positive thinking and self-efficacy; formation of motivation for achievement; development of positive thinking competence	art therapy, gestalt therapy, psychodrama, role play, cards with affirmations, technique of positive processing of an unpleasant situation "Magic questions", interactive exercises, technique "Positive language", case-study.	CBT Companion: (Cognitive Behavioral Therapy app). ACT iCoach: Acceptance Commitment Therapy App. 3DBear – Visualize your creative thinking.
7. Resources of the past, present, and future. Time management	formation of time management competence; awareness of the importance of a constructive attitude to the past, present, future in order to improve the emotional competence; competence development: being present "here and now", feeling and objectively perceiving reality, other people; tolerance to failures and uncertainty, ability for reasonable risk	case-study, gestalt therapy, role play, "aquarium", art therapy, relaxation techniques, "Box of Joy" technique, art therapy.	Diarize. Paint Draw AR Vaytricks. CubeAR: maze 3D & AR. VR Player Best video VR 360 video.
8. Social sensitivity. Non-verbal communication	awareness of emotional processes during interpersonal interaction; mastering skills of social sensitivity; expanding the range of emotions; competence development: identification, analysis, verbalization of the emotions and feelings of the interlocutor, understanding the reasons for their occurrence; emotional support; development of skills of attentive listening	art therapy, role play, brainstorming, transformation game, aquarium, interactive lecture, psychogymnastics, reflection technique, moderation, community emphasis technique, techniques of verbalization of your own and partner's feelings	eQuoo: Emotional Fitness Game. RakugakiAR.
9. The golden mean in communication. Assertiveness of behavior.	development of assertive behavior, adequacy of self-esteem, expanding the range of emotional response; development of competencies: selection of an emotional reaction adequate to the situation; constructive resolution of the emotionally tense situations, protection of your own psychological boundaries, your point of view; resistance towards manipulations; ability to refuse without offending another person	art therapy, role play, case study, interactive mini-lecture, facilitation, assertive refusal techniques, sharing	CBT Thought Diary - Mood Tracker. Timia. Ylands.
10. Career guidance game "Tree of professions"	activation of psychological readiness for professional self-identification; actualization of internal human resources for successful professional self-realization; formation of the ability to make a decision on choosing and obtaining a profession; systematization of ideas about the world of professions, development of skills of search and analysis of information, group work	art therapy, role play, case study, collage technique, transformation game, brainstorming, sharing	Expeditions AR. AR Sandbox. Arcraft - AR No Size Limit. VR - Virtual Work Simulator

Main Determinants of the Use of Cloud Technologies in the Development of Professional Stability of the Future Specialist in the Conditions of Adaptive Learning

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Keywords: Information and Communication Technologies (ICT), Cloud Services, Cloud Technologies, ICT Competence, Electronic Information and Educational Environment, Professional Stability, Working Capacity, Self-Actualization, Motivation, Vital Capacity, Mental State.

Abstract: The article considers practice-oriented possibilities of using cloud technologies in the process of development of the main components of professional stability of the future specialist of socionomic direction in the conditions of blended learning. The research is devoted to the use of cloud services in the formation of not only ICT competence, but also the development of professional stability of the future specialist. The study substantiates the importance of cloud services and analyzes the use of cloud technologies Google Workspace for Education, distance learning system Moodle in the modern information and educational environment of higher education. The authors clarify the didactic capabilities of cloud services and identify the psychological and pedagogical conditions for the development of components of professional stability, as a dominant integral of the competitiveness of the future specialist. The methodical aspects of designing the process of development of professional stability of the individual on the basis of the use of cloud services aimed at improving the mental capacity of the applicant of higher education are highlighted. In the framework of theoretical and methodological analysis of the problem of professional stability of the psychologist identified the following main components: cognitive, motivational, behavioral, emotional and volitional. Professional stability is closely interrelated with the processes of professional and personal development, professional adaptation, the level of efficiency of the individual. In the process of implementing the program of implementation of cloud technologies, the authors consider the professional stability of man as a dialectical synthesis of sustainability and variability, preservation and development. The results of the formative stage revealed significant positive changes in the manifestation of the components of professional stability of future professionals. Prospects for further research are the development of a comprehensive program for the use of cloud technologies in non-formal education and personalization of the process of professional development of future professionals.

1 INTRODUCTION

The field of education is experiencing a turning point, which is accompanied by the reorientation of higher education into an open educational system. Integration into the European educational environment requires the introduction of the latest methods, based on the use of information technologies, in the educational process of higher educational institution. Today, one of the main tasks of the educational system is to provide everyone with a free and open access to knowledge, taking into account their needs, abilities and interests. So far, the state of informatization of society has reached the point when innovations have flooded all spheres of life: the pace of technology renewal is impressive and it forces the scientific community to respond immediately to today's challenges. The primary need of higher education in the personifi-

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cation and individualization of education, due to quarantine measures caused by COVID-19, causes a rapid integration of cloud and innovative information technologies into the process of training a competitive, professionally stable specialist of the new format. The modern technologies are present at all levels and in all aspects of pedagogical activity – from the use of information technology in teaching a certain discipline to the implementation of systems of management in higher educational institutions.

Among the modern technologies, cloud technologies occupy a prominent place, they are increasingly penetrating the system of domestic education (Kiv et al., 2019). Until recently, cloud technologies were considered the prerogative of large corporations, but today they are used by small and medium-sized businesses, government and the educational system in general.

According to the latest statistics, about 77% of companies have been already using or plan to use the cloud technologies. 69% of them consider such a transition to be a necessary condition for the survival in a competitive changing world.

The cloud sphere, meanwhile, is actively developing and annually presents innovations in functionality and applications. 2020 is a year of restructuring and adaptation of a human being to the life in the new economic, social conditions of society in the post-coronavirus space. In the international press this year was called “the year of cloud technology”. Market giants IBM, Amazon and Microsoft started actively offering cloud infrastructure and platform as a service not only in the United States, which is the main country of data hosting, but also abroad, actively increasing its presence in other countries.

The use of cloud technologies in the educational process is one of the dominant areas for the enhancement of the quality of higher education, individualization and personalization of the educational process. The educational process is not left out of the renewal process, and one of the ways to solve the problem of interaction of several remote systems supporting the learning process, their mobility and cost-effectiveness is the use of cloud computing, when data resources are provided to final users as an Internet service (Morze and Kusminska, 2011).

The Concept of Development of Digital Economy and Society of Ukraine for 2018–2021 states the necessity of taking measures to implement appropriate incentives for the digitalization of the economy, public and social spheres. It also focuses on the issues of raising the awareness of existing challenges, using tools for digital infrastructure development, and developing digital competence. This Concept also identifies critical areas, circles out the digitization projects, plans stimulation of the domestic market of production, use and consumption of digital technologies. It is noted that the integration of Ukrainian science into the European research space will provide an opportunity to develop advanced scientific ideas, participate in interdisciplinary projects, focus on perspective ideas, technologies and innovations.

One of the important tasks is the formation of a profound national policy of digitalization of education as a priority component of educational reform, and one of the key elements of the Digital Single Market of Europe and a part of the paradigm “Open Innovation – Open Science – Openness to the World”, which is developing within the European scientific innovation space. There is also a need to develop a European cloud of open science and a European data infrastructure. The implementation of the main postulates of the Concept described above has been going on for some time, in particular, various scientific research works in this direction are being carried out in Ukraine.

The dynamism of national processes, taking place in modern Ukrainian society, creates a socio-cultural and educational situation, the way out of which is directly related to the enhancement of the quality of training and the increase of the level professionalism of future professionals who are capable of self-transformation and are ready for full self-realization in unstable, changing working conditions.

Future professionals’ awareness of the relationship between the requirements of the profession and their personal characteristics encourages the construction of their own personality in the framework of professionalization, consequently it creates conditions for becoming a professional.

The issue of students’ own social mobility, readiness for self-education in the new information field, in which integration competence plays an important role, is becoming an urgent issue for modern Ukrainian student youth.

The issue of professional stability is also an important one, which is also a practical aspect of a broader problem – the problem of competitiveness, efficiency and readiness for professional self-realization in today’s unstable conditions of professional activity. Accordingly, it is also very important to find priority ways to provide educational services, taking into account the future specialist’s individual psychological characteristics and innovative trends of cloud technologies use in the process of future professionals’ training.

2 LITERATURE REVIEW

The issue of creating cloud services is very popular in today's world, where the priority is a rapid development of information technologies and their use in public spheres. Many analytical companies study the development market, build cloud services and implement them into practice. The main purpose of professional training is to develop such a potential of a specialist, which would ensure not only the quality of his professional duties, but also professional self-improvement. In the conditions of transformation of a society the problem of adaptation of future experts to fast changes both in social and economic, and in cultural and educational spheres of life acquires special sense. Today's dynamic, competitive society requires the training of a new type of professionals, namely those who could be creative, unconventional in decision-making, be mobile and effectively carry out professional activities. Forrester Research has assessed the current dynamics of cloud storage popularization and concluded that by 2020 the cloud computing market will be $ 241 billion (Thompson, 2008).

In the world's developed countries, the technology of cloud computing is becoming more and more widespread. In the domestic market, they are also actively penetrating public infrastructure.

Infrastructure as a service (IaaS) is a model of providing on-demand remote access to a common pool of configurable computing resources (cloud infrastructure) with the ability to manage them independently.

The foundations for the creating and rapid development of cloud technologies were:

- technical progress, rapid development of hardware: the ever-increasing power of processors, development of multi-core architecture and increase of the hard disk storage capacity;
- high power Internet channels;
- ”large” Internet services, cloud data storage;
- impact of quarantine conditions caused by COVID-19, combined with the need to perform certain activities.

Cloud storage is a model of online storage in which data is stored on numerous networked servers which are provided to customers mostly by a third party. Data is stored and processed in the cloud, which is, from the client's point of view, one large virtual server. It should be noted that the cloud is not the Internet itself, but the whole set of hardware and software that provides processing and execution of customer's requests. There are not many authoritative sources that define the concept of cloud computing. The most comprehensive and fundamental approach to this issue was proposed by Mell and Grance (Mell and Grance, 2011): they define cloud computing as a model of providing convenient on-demand network access to a shared set of parameters, computing resources (e.g., networks, servers, data storages, applications and/or services) which the user can quickly use, when executing their own task, and free up while minimizing the number of interactions with the service provider or their own management efforts. This model is aimed at the increase of the availability of computing resources and combines five main features, three service models and four deployment models.

Characteristics of cloud computing:

1. Self-service on demand. The consumer, when he or she needs it, can use computing capabilities, such as server time or automatic network storage, without interaction with the staff of the service provider.
2. Wide availability via the network (Internet). Opportunities are available online; they are accessed on the basis of standard mechanisms; it ensures the use of heterogeneous thin and thick client platforms (e.g., mobile phones, laptops, PDAs).
3. Combining the resources into a pool. The provider combines its computing resources into a pool in order to serve a large number of customers using the principle of multitenancy. Different physical and virtual resources are dynamically distributed and redistributed according to the user's needs. There appears a sense of location independence when the customer does not know where the computing resources they use are, but may be able to identify their location on a more abstract level (e.g. country, region or data center). Examples of resources can be data storage, computing power, RAM, bandwidth, virtual machines.
4. Ability for quick adaptation. Computing capabilities can be quickly and flexibly reserved (often automatically) for prompt scaling according to the customer's tasks, and also quickly vacated. From the consumer's point of view, the available options often look unlimited and can be purchased in any quantity and at any time.
5. Measurable service. Cloud systems automatically control and optimize resource utilization by measuring some abstract parameters. The parameters vary depending on the type of service. For example, they may be: data storage size, computation power, bandwidth and/or number of active user's records. Resource use is tracked, controlled; reports are generated. Thus, both the

provider and the consumer receive transparent information about the range of services provided (consumed).

Cloud technologies represent a new paradigm that provides a distributed and remote processing, data storage; they lead us to a new concept of using Internet resources in today's educational environment.

The analysis of modern scientific research works has shown that there exists the experience of using cloud platforms and virtualization technologies, including those based on the virtual machines from Microsoft, Amazon, Google, Yandex, for the organization of universal workplaces for students with unification of system and application software for individual learning. Shevchuk et al. (Shevchuk et al., 2020) studied the main advantages of cloud software over traditional academic tools used in the educational environment. The authors paid attention to the organization of a virtual workplace in order to increase the effectiveness of learning both in the educational institution and outside the classroom.

Analyzing the possibilities of using cloud technologies as a component of future specialists' professional training, taking into account personal psychological characteristics, Kolesnyk et al. (Kolesnyk et al., 2020) demonstrated a structural model of information and media literacy of university entrants and the use of cloud technologies in the education for sustainable development. Kolesnyk et al. (Kolesnyk et al., 2020) analyze the levels of formation of such type of entrants' literacy in the process of their sustainable development (cognitive, constructive-exploratory, creative and productive levels). Kolesnyk et al. (Kolesnyk et al., 2020) developed a method of interaction of information and media literacy with cloud technologies in the educational process.

Osadcha et al. (Osadcha et al., 2020) research the current state and relevance of the use of adaptive learning systems and cloud technologies as useful tools for the development of an individual learning path leading to the highest level of intellectual development in accordance with natural abilities and inclinations. Taking into account the technological progress and the actualization of STEM education, the priority is the research work done by the Valko et al. (Valko et al., 2020), they focused on a detailed description of the introduction of cloud sources in the development of robotic systems.

Analyzing the combination of traditional classroom education and distance learning, Petrenko et al. (Petrenko et al., 2020) focused on the possibilities of using cloud technologies in the process of organizing distance learning and the implementation of a comprehensive competency-oriented approach.

The practice-oriented research of the staff of the research laboratory "Cloud Technologies in Education" of Kryvyi Rih National University and the Institute of Information Technologies and Textbooks of NAES of Ukraine demonstrates ways to implement models of cloud services SaaS, PaaS, IaaS, which should be used in the process of doing the courses on mathematical, natural cycles while organizing future specialists' professional-practical training in the field of information technology (on the example of software engineering, computer science and computer engineering). Scientists have identified the most significant advantages of using cloud technologies in future specialists' training in information technology, namely the possibility of using modern parallel programming tools as the basis of cloud technologies (Markova et al., 2019). Thus, cloud technology is not only a modern trend of effective use of information and communication technologies in professional activities, but also a proven tool of educational activities (Fedorenko et al., 2020).

Analysis of literature sources has shown that the issue of development and implementation of cloud services in the process of training of competitive future professionals is an important area and it requires additional practice-oriented empirical research in order to expand the possibilities of creating cloud technologies and to implement them successfully not only in the sphere of education but also in other no less important areas of human activity.

3 RESEARCH METHODS

Interdisciplinary research was conducted as part of research work carried out at the expense of the general fund of the state budget: "Adaptive system for individualization and personalization of future professionals' training in the conditions of blended learning", state registration number: 0120U101970. Taking into account the pandemic conditions and social isolation, from 2019 to 2020 on the basis of Bogdan Khmelnitsky Melitopol State Pedagogical University in the context of the program "Development of professional stability of the future specialist in the conditions of information and educational transformations" the implementation of the psycho-correctional program, based on the elements of cloud technologies, was proposed. The following methods were used in the research process: method of theoretical analysis of literature sources on the introduction of cloud technologies in the educational process of higher educational institution and on the implementation of distance learning based on the principles of adaptive and personalized learning; analysis of modern experience of psychological and pedagogical support of integrative process of future specialist's professional stability development; systematization of practical experience of enhancing the person's working capacity in higher educational institution; analysis of the practical implementation of Google Workspace for Education in the program of the future specialist's professional stability development; a set of psychodiagnostic examinations using Google Form; experimental study consisting of two stages: ascertaining and formative.

4 RESEARCH RESULTS

4.1 Theoretical Foundations

Modern information and educational environment of the university is analyzed in the context of the electronic display of various aspects of the university activity on the Internet. There are different plans for designing the e-learning environment that take into account the interests of different groups of network users. From the socio-psychological standpoint, the electronic educational environment of the university takes an active part in the improvement of educational technologies, emergence of new aspects of teaching activity, and creation of the conditions of students' self-realization.

Example of modern cloud-based services for educational institutions is Google Workspace for Education. Google's online services for educational institutions have a number of advantages, which makes it possible to use them in any educational environment where there is an Internet connection (figure 1).

Modern computer technology allows students, teachers and researchers to use several devices for the communication and work: laptops, computers, smart phones, mobile phones, etc. Google Workspace tools are supported by a variety of devices, so it is a widely available and universal IT technology to work with in the modern educational environment. Google Workspace include more than sixty free services that can be connected to one domain, including video hosting service YouTube, CMS Blogger, Google Analytics, organization chart service Lucid Chart, graphic editor Aviary, etc. They are easy to use, are serviced by Google and do not require downloading, installing or maintaining hardware or software. In addition to its diversity, which meets any needs of the modern teacher, Google applications have such characteristics as accessibility, simplicity, reliability, low cost, stability, variability, quality. The additional arguments in favor of choosing Google services and other services for the educational purposes are the availability of special applications for phones and tablets, centralized data storage, information security and Ukrainian interface. Google Workspace for Education combines a number of useful services, such as:

- Gmail – a free e-mail service;
- Classroom – assistance of learning;
- Drive – file hosting using cloud technologies;
- Calendar – time planning;
- Vault – archiving and management of user's data;
- Docs – a set of tools for working with office files;
- Sheets – processing of data presented in the form of spreadsheets;
- Forms – creating online forms and conducting surveys;
- Slides – creating presentations, regardless of the available device;
- Sites – a platform for hosting and a designer for creating sites;
- Meet – interactive communication and video conferencing tool.

The above mentioned services can be used both separately and in combination, as a complement to each other.

Today, one of the most well-known and widely used services for organizing learning of students is Google Classroom (https://classroom.google.com). Its use allows you to organize effective interaction of all participants of the educational process, distribute educational materials and provide the execution of various educational tasks with necessary software, assessment of students' learning outcomes. Google Classroom provides a user-friendly interface for creating and managing training courses. It gives a wide range of opportunities for the organization of the educational process in higher educational institutions. The service has all necessary facilities for the communication, task setting and testing. Also, the use of Google Classroom helps to increase learning motivation; saves time for the preparation; provides clear and interactive information, so it contributes to better assimilation of information. The use of Google Classroom in the process of future professionals' training systematizes the work of all participants of the educational process and takes it to a higher level.

Taking into account the dominant advantages of using Google Classroom in the organization and monitoring of the educational process in the university and certain quarantine restrictions due to COVID-19,

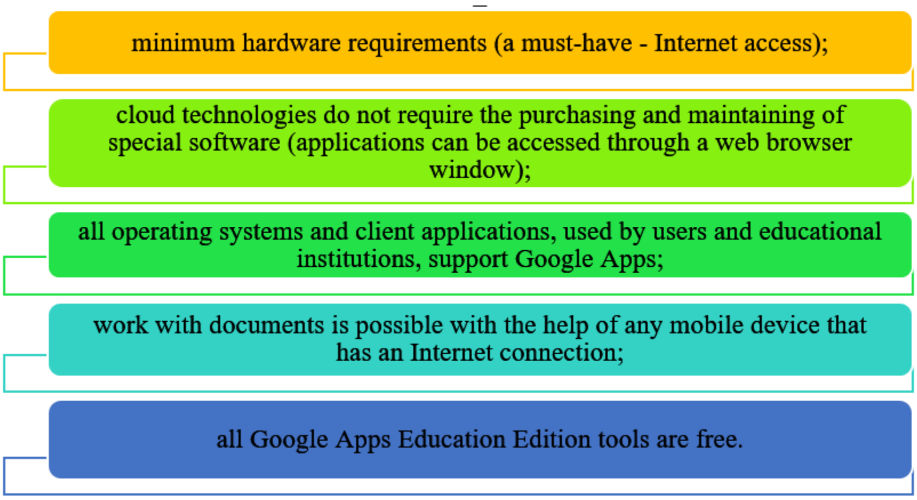

Figure 1: Main features of Google Workspace for Education use in education from the user's point of view.

the priority in the context of our study was given to the development, testing and implementation of a comprehensive program "Development of professional stability as a factor of future specialist's psychological security in terms of information and educational transformations". This program was being piloted during 2019–2020 as part of the scientific and practical online course "Modern innovative technologies in education and psychology" (Osadchyi and Varina, 2020). The purpose of this online course is a practice-oriented implementation of the competence-based approach in the process of training future specialists in socionomy. It also aimed at the improvement of future educators and psychologists' professional skills and competencies in order to create better opportunities for the use of modern practice-oriented technologies in the educational process. This online course consists of four modules and is based on the use of Google Classroom. It is 90 hour, 3 ECTS credit online course which includes four modules:

Module 1. Worldview foundations of professional development of specialists of socionomic professions

Content lines:

1. Information part. State strategy of education development. Legislative support of the system of education and professional development of teachers in Ukraine. A healthy and safe environment of an educational institution as a component of professional well-being and development.
2. Practice-oriented part. Value and activity principles of teacher and psychologist's professional development. Specialist's speech competence. Information and media literacy as a key competence of a digitalized society and the main condition for quality education.
3. The part is aimed at developing the professional stability of the individual. Implementation of practical tasks and group training exercises on "Professional resilience as a means of overcoming complex professional tasks and life situations". The main directions of the introduction of innovative psychotechnologies:
   - Styles of overcoming behavior in the decision-making process under conditions of uncertainty while performing professional tasks;
   - Resource components of personality and their development;
   - Social environment as a resource for the development of professional stability. Team building and corporate ethics of interpersonal interaction.

Module 2. Development of modern specialist's psychological and pedagogical competence.

Content lines:

1. Information part. Fundamentals of inclusive education, children with special educational needs: peculiarities of learning and development, psychological and pedagogical conditions for their assistance in the educational process, universal design in education. Establishment of the safe educational environment, prevention of bullying and its

overcoming in the educational institution, modern problems of adaptation and socialization of the students; formation of students' social competencies in the process of neuromanagement. Pedagogy of partnership: interaction with teachers, parents, local authorities, and community. Psychological support of talented children.

2. Practice-oriented part. Development of specialists' emotional competence. Specialists' psychological competencies: psychological features of the child's development at different age stages, strategies and tactics of professional and personal burnout prevention, psychology of team building; psychodiagnostics of student's personality, psychodiagnostics of educational management.
3. The part is aimed at developing the professional stability of the individual. In this block, group lessons were implemented aimed at developing the emotional component of professional stability and goal-setting skills:
   - Professional stability and psychological well-being as determinants of the competitiveness of a future specialist;
   - Professional stability as an alternative to learned helplessness;
   - The art of setting and achieving professional goals;
   - Personal formula for professional success

Module 3. Organizational and methodological principles of the development of specialist's professional competencies.

Content lines:

1. Information part. Practical psychologist's educational and preventive work in the educational institution. Counseling as a method of psychological influence. The use of art-therapeutic techniques in the educational process. Conflict prevention and resolution using renewable techniques. Functioning of psychological service in the system of education in the conditions of the New Ukrainian school: legislative base.
2. Practice-oriented part. Development of a practical psychologist's digital competence:
   - protection of personal data on the Internet, safe use of digital technologies and services; legal and ethical requirements for the use of information and communication and digital technologies in professional activities;
   - cloud services in the professional activity of a specialist; streamlining digital educational resources, ensuring accessibility, organizing the interaction of participants in the educational process;
   - use, creation, design and distribution of digital educational resources;
   - use of distance learning technologies; virtual class: an overview of the resources for creating a virtual class; creation and organization of the educational process;
   - preparation of a distance course: selection of a platform for webinars, educational process planning, preparation of a scenario for a webinar; providing interactive distance interaction of participants in the educational process;
   - specialist's digital portfolio; working with documents; creating and compiling a portfolio using a site (blog).
3. The part is aimed at developing the professional stability of the individual. In this block, a personality-oriented approach is implemented in the process of updating the creative potential of future specialists. Students researched and used the mechanism of creativity for the development of resource components of professional sustainability. The following group training sessions were held:
   - Creative creativity as a resource for development professional stability;
   - Professional and personal potential as the foundation of creative creation.

To achieve an effective result, students are familiar with the "Quest of resilience" methodology to prevent the devaluation of their own achievements in the process of solving practical professional problems.

Module 4. Introduction of innovative technologies into various spheres of psychological and pedagogical activity.

The subject of study – modern practice-oriented technologies and methods of psychological assistance of individuals and groups. The purpose – acquaintance with and internalization of innovative practice-oriented technologies in practical psychologist's activity.

Content lines:

1. Information part. Innovative technologies for working with children with special educational needs. Development of interhemispheric interaction by the method of kinesiology. Innovative coaching technologies in a modern specialist's activities. Innovative art-therapeutic technologies in various spheres of public practice. Case-study technology in a modern specialist's educational work. Supervision in psychological practice: modern realities.
2. Practice-oriented part. Within this block, future specialists developed, implemented and analyzed the effectiveness of the developed training program, focused on solving current social problems. Based on the results of the implementation, students wrote down in online format a qualitative and quantitative analysis of the effectiveness of the implementation of a personal training program.
3. The part is aimed at developing the professional stability of the individual. In this block of the module, group lessons are implemented, focused on the development of the general level of individual resilience:
   - Development of communication skills as an element of "involvement" (according to S. Maddy);
   - Development of teamwork skills, conflict-free communication skills as an element of "involvement" (according to S. Maddy);
   - Development of skills of confident behavior as an element of "involvement" (according to S. Maddy);
   - Development of skills of stress-resistant behavior as an element of "control" (according to S. Maddi);
   - Teaching relaxation skills, self-control emotions as an element of "control" (according to S. Maddy);
   - Development of the ability to set a goal as an element of "control" (according to S. Maddi);
   - Development of self-knowledge as an element of "risk taking" (by S. Maddy);
   - Development of a positive Yconception as an element of "risk taking" (according to S. Maddy)

Due to the practical orientation of this online course, its structure includes a comprehensive training program "Development of professional stability of the future specialist in the conditions of information and educational transformations", which was conducted using Google Classroom cloud technology. In order to provide feedback and stimulate sharing with the participants of the training group, the technical capabilities of Google Meet and the Trapscan application (psychological diary) are used. The application uses one of the main methods of cognitive-behavioral therapy – ABC analysis. The role of thoughts in shaping the mood and well-being of the individual is very significant and it is not the situation that affects what emotions a person feels, but the perception of this situation. The application allows you to keep a diary and analyze personal reactions, work with your thinking, improving the quality of your life. Duration of this training: 18 hours (9 classes of 2 hours each). The duration of each class may slightly vary depending on the degree of participants' interest and the actualization of their problems.

When indentifying the essential characteristics of specialist's professional stability, we took into account the following methodological ideas:

- stability is a qualitative characteristic of any object, system or individual; thus, quality means some certainty of the subject or the individual possessing certain specific features;
- stability is manifested in holistic systems, self-organization of which is impossible without the existence of a hierarchical structure of internal factors;
- stability of the psychologist's personality is formed in the process of self-identification and professional development and is manifested in the work and active self-organization;
- stability is the result of the functioning of mechanisms that actively counteract the negative influencing factors (Moore and Foxx, 2020).

The developed model of structural components of future specialist's professional stability acts as a theoretical and methodological basis for the development and implementation of this training program (figure 2). As a result of theoretical analysis, we have identified the following components in the structure of the future specialist's professional stability.

Based on the model of development of future specialist's professional stability, as a factor of effective mental capacity of the individual, all structural parts of the training were divided into the following blocks:

- formation of psychological readiness to work in new transformational conditions;
- development of psychological awareness of various aspects of professional activity;
- enhancement of personal efficiency and working capacity;
- development of specialists' personal stress resistance to the growth of mental load and work in the new information conditions;
- formation and development of professionally significant cognitive qualities;
- development and improvement of skills and abilities to establish psychological contact with different categories of citizens;
- formation of skills of role behavior in different situations of professional activity;
- improvement of the ability to apply psychological and pedagogical methods of influence in the complicated conflict situations of communication;
- formation of the ability of psychological stability in tense situations of professional activity;
- development of personality's positive emotional and volitional qualities, training of specialists in self-regulation and self-management;
- formation of volitional activity and skills of volitional actions;
- development of positive internal motivation to carry out effective professional activity;
- preparation for mental overload at work.

The structure of each unit included three elements: 1) acquaintance with the characteristics of a particular trait that was developed, a metaphorical explanation of the content and objectives of the unit, "warming-up" activities; 2) the main part; 3) reflection on the unit as a whole.

The training program was designed and piloted taking into account the following principles: the principle of purposeful creation of emotionally colored situations (active influence on the individual, creation of appropriate conditions for the perception and assimilation of new knowledge that is emotionally colored and has personal significance); the principle of personal developmental communication (understanding, recognition and perception of personality); the principle of using empathy as a psychological mechanism in the education of personality (includes two cognitive components – the ability to distinguish and name the emotions experienced by other people and take another person's position; and the emotional component – the ability to respond emotionally); the principle of systematic analysis of one's own actions and the actions of others (it contributes to the formation of the ability to predict the above mentioned results and has a positive effect on the development of behavioral skills of overcoming instantaneous aspirations, states, desires).

The program is created in accordance with the principles of the Accelerated Learning Theory and implies all the latest advances in the field of methodology of teaching adults.

4.2 Experimental Results of Research

While conducting a formative experiment based on the piloting of a comprehensive training program "Development of professional stability of the future specialist in the conditions of information and educational transformations" we introduced the practical online course "Modern innovative technologies in education and psychology" in order to identify the effective psychological and pedagogical conditions for the development of professional stability, as a factor the specialist's mental capacity. After conducting the formative experiment we compared the results of two psychodiagnostic assessments. The sample was randomized and consisted of 58 people who did practical online course "Modern innovative technologies in education and psychology" – 30 people, future professionals in psychology, who participated in the training program and 28 people, future professionals, who didn't take part in the training program. The psychodiagnostic unit of the study included a survey using Google Forms.

According to the analyzed structural components of professional stability of the personality in the psychodiagnostic block the following techniques were carried out:

- For successful higher education and maintaining the optimal level of professional stability of students, it is important to have a valuable motivation to study. For this purpose, we used the method of "Motivation to study at university";
- Methodology "Questionnaire to determine the level of socio-psychological stress", aimed at identifying the level of manifestation of socio-psychological stress in future professionals at dif-

COMPONENTS OF THE FUTURE SPECIALIST'S PROFESSIONAL STABILITY

<table>
<tr><th>Motivational component</th><th>Cognitive component</th><th>Connotative component</th><th>Reflexive-valuable component</th><th>Regulatory-volitional component</th></tr>
<tr><td rowspan="2">Motives related to the attitude to the future professional activities</td><td>Awareness of the patterns of future professional activity in the field of practical psychology</td><td rowspan="2">Skills of organizing and finding a creative solution of problems in future professional activity</td><td>Ability for reflection</td><td>Volitional regulation of future activities</td></tr>
<tr><td>Awareness of the principles, directions, technologies of professional activity</td><td>Value orientations in future professional activity</td><td>Ability for self-regulation</td></tr>
<tr><td>Motives related to the development of professionally significant personal traits</td><td>Subject-specific knowledge</td><td>Skills and abilities of professionally stable behavior</td><td rowspan="2">Readiness for productive communication and establishment of trusting relationships (level of development of communication sphere and empathy)</td><td>Volitional regulation at the stage of self-development</td></tr>
<tr><td>Motives of achievement</td><td>Knowledge about oneself</td><td>Ability to restructure behavior and activities in changing conditions (adaptive capabilities of the individual)</td><td>The level of emotional regulation development</td></tr>
</table>

Figure 2: Structural components of future practical psychologist's professional stability.

ferent stages of professional genesis, which affects the indicators of their overall level of professional stability;

- Methodology "Coping behavior in stressful situations", aimed at identifying the dominant coping stressful behavioral strategies in students. Obtaining these data allows a more thorough study of the psychological conditions for the development of their professional stability, because only a constructive coping response to stress, aimed at rational analysis of the problem and solve a complex stressful situation, allows future professionals to overcome difficulties and successfully solve professional problems without reducing performance.
- "Questionnaire DORS – Differentiated assessment of states of reduced efficiency (fatigue-monotony-oversaturation-stress)", which is aimed at determining the degree of manifestation of each of the physiological states of personality stability (fatigue-monotony-saturation-stress). The development of these states leads not only to a decrease in resistance, but also affects the qualitative characteristics of behavior and emotional coloring of

experiences, which provokes significant changes in the motivational sphere of personality.

The analysis of the results of piloting the system of psychological and pedagogical measures showed the significant differences between the control and experimental groups in terms of indicators of professional stability and the development of its psychological and pedagogical conditions. Significant changes in the indicators have been traced according to all the methods used. In order to identify the significance of the changes that occurred after the correction work, we used the G-criterion (Varina and Shevchenko, 2020). The G-criterion is used for the establishment of the general direction of sign shift under research. We put forward the hypotheses:

H_0: The predominance of the typical direction of shift between the obtained data is accidental.

H_1: The predominance of the typical direction of shift between the obtained data is not accidental.

This work contributed to the effective formation of experimental group specialists' value motivation for learning (table 1).

As we can see from table 1, in the experimental group there was an increase by 16.66% in the number of people wishing to master the profession (from 10.00% to 26.66%). It means that they rethought themselves as future professionals; they started demonstrating the desire to develop professionally important qualities, to become an educated person and a high-caliber professional. In addition, the number of people, who are focused on the acquisition of certain professional knowledge, showing curiosity, purposefulness and independence in the process of knowledge acquisition, has slightly increased (from 33.36% to 36.67%). Due to this, there was a decrease by 20.01% in the number of respondents who considered getting a diploma or professional certification as a priority of learning. That is, it can be stated that after conducting some activities the motivation for learning of the experimental group respondents has become more valuable. Having analyzed the indicators of the control group, we saw only a few changes. There was a shift of only 3.57% in motives of mastering the profession and getting a diploma. Also, according to the results of correlation analysis it was found out: with $n = 108$, typical shift is positive. Negative shifts – 32.

$$G_{contr} = \begin{cases} 45(p \leqslant 0.05) \\ 42(p \leqslant 0.01) \end{cases}$$

G_{emp} – a number of untypical shifts, so $G_{emp} = 32, G_{emp} < G_{contr}$. It means that H_0 is not proved, but H_1 is accepted.

It is also necessary to note significant changes in the manifestations of the level of socio-psychological stress of the experimental group students (table 2).

As we can see from table 2, after the introduction of the training program, in the experimental group there was an increase by 13.34% (from 33.33% to 46.67%) in the number of people with a low level of stress and there were no people with a high level of this indicator. Future professionals have stopped perceiving the process of adaptation to the introduction of information, cloud technologies in the educational space as that associated with stress. There was a slight decrease of the medium level of this indicator (from 63.3% to 53.33%), which proves the effectiveness of the development of the experimental group students' personal stress resistance, their ability to tolerate stress. There are only a few changes in the control group. Having used the G-criterion, we found out that the changes were due to the implementation of the correction program, but not thanks to the external artifacts that threaten the internal and external validity of the experiment. With $n = 115$, the typical shift is positive. Negative shifts – 38.

$$G_{contr} = \begin{cases} 45(p \leqslant 0.05) \\ 42(p \leqslant 0.01) \end{cases}$$

G_{emp} – a number of untypical shifts, so $G_{emp} = 38, G_{emp} < G_{contr}$. It means that H_0 is not proved, but H_1 is accepted.

The formation of the effective individual behavioral styles to overcome stressors after conducting experimental activities is confirmed by the following data (table 3).

The table 3 shows the increase in the percentage of participants of the experimental group (from 23.33% to 36.66%) who choose coping, focused on solving the problem, and a significant decrease (from 70.00% to 50.00%) in the number of people who prefer to avoid coping in stressful situation. That is, thanks to the work done, future specialists in situations of stress and uncertainty have become more focused on rational analysis of the problem, its constructive solution, they try to create and implement a plan to solve a complex stressful situation, rather than just blindly avoid their problems applying protective mechanisms or compensating for problems as before. In addition, in the experimental group, the number of people, who prefer not to think about problems at all, involving others in their experiences, trying to forget in a dream or compensate for negative emotions with food, decreased by 6.67%. Analyzing the changes in the control group, we can state in general the same indicators. With $n = 58$ typical shift is positive. No negative changes were identified.

Table 1: Learning motives of the experimental group ($n = 30$) control group ($n = 28$) specialists according to the formative experiment results.

Learning motives	**Experimental group**		**Control group**	
	before	**after**	**before**	**after**
Knowledge acquisition	33.36 (10)	36.67(11)	28.57 (8)	28.57 (8)
Mastering the profession	10.00 (3)	26.66 (8)	7.14 (2)	10.71 (3)
Getting the diploma	56.66 (17)	36.67 (11)	64.29 (18)	60.71 (17)

Table 2: Quantitative indicators (%) of levels of social-psychological stress of experimental ($n = 30$) and control ($n = 28$) groups students after the formative experiment.

Level of social-psychological stress	**Experimental group**		**Control group**	
	before	**after**	**before**	**after**
Low level	33.33 (10)	46.67(14)	39.29 (11)	42.86 (12)
Medium level	63.33 (19)	53.33 (16)	57.14 (16)	53.57 (15)
High level	3.34 (1)	0 (0)	2.57 (1)	3.57 (1)

$$G_{contr} = \begin{cases} 13(p \leqslant 0,05) \\ 10(p \leqslant 0,01) \end{cases}$$

G_{emp} – a number of untypical shifts, so $G_{emp} = 0, G_{emp} < G_{contr}$. It means that H_0 is not proved, but H_1 is accepted.

The introduction of the training program based on the cloud technologies has had a positive impact on all states of the reduced capacity, in particular among the experimental group participants.

Thus, there was an increase of 10.00% (from 10.00% to 20.00%) in the number of people with a low level of fatigue, which indicates that future professionals perform mental work online without exhaustion and significant errors. Due to this, the number of respondents with medium indicators of this state decreased by 3.33% (from 83.33% to 80.00%). Future specialists gained skills of rational organization of mental activity, which allowed them to get rid of high-level indicators on this parameter (from 6.66% to 0), which proves the ability of students to perform mental activities and tasks without deterioration of the working capacity. Analyzing the indicators of this state manifestation in the control group, only partial shifts were noted (a number of people with a high level decreased by 3.57% and a number of people with a medium level of fatigue increased accordingly). With $n = 58$ typical shift is positive. Negative shifts – 37.

$$G_{contr} = \begin{cases} 50(p \leqslant 0,05) \\ 46(p \leqslant 0,01) \end{cases}$$

G_{emp} – a number of untypical shifts, so $G_{emp} = 37, G_{emp} < G_{contr}$. It means that H_0 is not proved, but H_1 is accepted.

Accordingly, the work, which was carried out, also affected the indicators of monotony. It has to be noted that significant changes are noticeable in the experimental group. Therefore, the indicator of a high level of monotony decreased by 6.66% (from 10.00% to 3.34%). The participants demonstrated an increase of attention and the general ability to strong-willed efforts, they showed their general inclusion in innovative mental work. It should be noted that the number of people with a medium level decreased by 3.33% (from 76.66% to 73.33%) and the number of students with a low level of monotony decreased by 9.99% (from 13.34% to 23.33%). By developing the ability to gradually approach the perception and performance of intellectual actions, gradual mobilization and appropriate adjustment of the body to more effective execution of these actions, students learned to adaptively perceive the latest online intellectual activity, while maintaining a high level of working capacity. Assessing the indicators of this state manifestation in the control group, we noted only partial changes (there was a decrease in the high level by 3.58% and, accordingly, an increase in the medium level of manifestation of monotony). With $n = 40$ typical shift is positive. There were no negative shifts identified.

$$G_{contr} = \begin{cases} 14(p \leqslant 0,05) \\ 12(p \leqslant 0,01) \end{cases}$$

G_{emp} – a number of untypical shifts, so $G_{emp} = 0, G_{emp} < G_{contr}$. It means that H_0 is not proved, but H_1 is accepted.

According to the indicator of mental oversaturation, it was found out that due to the introduction of highly efficient cloud technologies in the development of professional stability (namely, diversification and emotional saturation of mental activity in the process of performing practice-oriented tasks), low level of this state increased by 13.33% (from 26.67%

Table 3: Features of coping reactions to stress in experimental ($n = 30$) and control ($n = 28$) groups according to the results of the formative experiment.

Coping-behaviour in stressful situations	**Experimental group**		**Control group**	
	before	**after**	**before**	**after**
Coping oriented for the solution of the problem	23.33 (7)	36.66 (11)	28.57 (11)	32.14 (9)
Coping oriented for the emotions	6.67 (2)	13.34 (4)	7.14 (2)	7.14 (2)
Coping oriented for the avoidance	70.00 (21)	50.00 (15)	64.29 (18)	60.72 (17)

to 40.00%), so future professionals have learned to perceive mental activity without a wish to stop it. Accordingly, the indicators of the medium level of oversaturation decreased by 13.33% (from 73.33% to 60.00%), indicating the formation of respondents' ability to accept subjectively uninteresting activities without changing the stereotype of performing reasonable actions. In the control group the oversaturation indicator remained unchanged. With $n = 58$ typical shifts are positive. Negative sifts – 37.

$$G_{contr} = \begin{cases} 50(p \leqslant 0,05) \\ 46(p \leqslant 0,01) \end{cases}$$

G_{emp} – a number of untypical shifts, so $G_{emp} = 37, G_{emp} < G_{contr}$. It means that H_0 is not proved, but H_1 is accepted.

Thanks to this work done, it was possible to increase by 16.67% the number of people with a low level of stress (from 20.00% to 36.67%), which indicates an increase in their stress resistance and the formation of skills of self-regulation of their own psychophysiological state. Due to this, the number of people with a medium level of this state decreased by 16.67% (80.00% to 63.33%), they have an experience of overcoming a difficult stressful situation. In the control group the indicators of stress remained almost unchanged.

The training work helped to increase students' neuro-psychological stability. According to the formative experiment results, there was an increase in the level of neuro-emotional stability in both experimental and control groups. But more significant changes took place in the experimental group. In particular, the number of people with a low level of neuro-emotional stability decreased by 10% (from 66.66% to 56.66%) and the number of people with a high level of this indicator increased by 10%. This states that the respondents have become more optimistic about the reality when doing the educational activities in the online format under quarantine restrictions. They adequately perceive new transformational innovative requirements of the intellectual and educational environment. These shifts in the control group were shown only partially (there was a decrease by 3.57% in the number of people with a low level and, accordingly, there was an increase in the number of people with a high level of neuro-emotional stability).

Thus, the results of statistical processing of empirical data proved the effectiveness of the training program, based on cloud technologies, in the process of developing the future specialists' professional stability in the modern educational environment. The corresponding program, in contrast to the traditional training, has certain advantages, which were identified according to the feedback, received from the participants:

- personal orientation and personification;
- possibility of in-depth study of personal problems;
- psychological and emotional security;
- free timing and autonomy in performing practice-oriented tasks; selection of the tasks depending on personal requests, etc.

5 CONCLUSIONS AND RECOMMENDATIONS FOR FUTURE RESEARCH

Despite the great variety of information and communication technologies, used in education, and the diversity of the educational environment, the innovative systems, based on the use of cloud services, are significant from the point of view of all participants of the educational process. And if the traditional management system of the educational process is a "vertical" educational technology that reflects the traditional model of learning in the modern educational environment, the use of cloud technologies in the revolutionary reform of education, implies "horizontal" educational technology of cooperation, collaboration, networking community. Thus, modern cloud technologies provide an opportunity to design and construct a new learner-centered information environment, taking into account the individual psychological characteristics of students, so such system goes in line with principles of personification and individualization of modern information. It contributes to the introduction of new methods of educational process construction, interaction and management. All mentioned above determines the psychological and pedagogical feasibility and didactic significance of the use of cloud services for modeling and implementing the components of the educational environment under the conditions of quarantine and social isolation, which can not be an obstacle to future specialists' professional development and growth. There is also a need to include the ability of students to create an educational environment with the help of cloud technology services as part of future specialists' information competence.

The piloted model of the development of future specialists' professional stability with the help of cloud services will not only form professionally important competencies, but also generate students' knowledge about the functions and capabilities of modern information technologies and cloud services, which will modernize education as a whole. Further research should include the development of technologies for this model introduction, taking into account the individual characteristics of students in the process of online learning. We also see the perspectives of the research in the integration of cloud technologies in formal and non-formal education, identification of conditions and opportunities for the monitoring of the individualized and personalized training of future professionals.

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The State of ICT Implementation in Ukrainian General Secondary Education Institutions in 2019 and 2020

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Keywords: Information and Communication Technologies, Cloud Technologies, Cloud Services, Game Simulators, Simulators, Massive Open Online Courses, General Secondary Education Institutions.

Abstract: The use of digital technology in various fields of education today is one of the most important trends in the educational process in the world. The article presents the results of the analysis of the current state of implementation of ICT in the educational process of institutions of general secondary education in Ukraine. For this purpose, a survey was conducted among students of the first year of the Zhytomyr Polytechnic State University of 2019 and 2020 years of admission, within which 17 questions were asked to students related to the use of information and communication technologies in the educational process. As a result of the research, the introduction of the discipline “Educational technologies and digital education” into the training of future information technology specialists was substantiated, as well as the certification educational program “Information systems and cloud technologies in the educational process”, designed for general education teachers, educators for higher education institutions, experts in the field of additional educational services, and other professionals. Besides, the course “Application Packages” for specialties 121 “Software Engineering”, 122 “Computer Science”, 123 “Computer Engineering”, 125 “Cybersecurity” and 126 “Information Systems and Technologies” at the Zhytomyr Polytechnic State University has been expanded for study some cloud services that can serve as an alternative to the usual MS Office. In conclusion, we can conclude that the positive dynamics in the use of various ICT tools in education is present (in comparison with school graduates in 2019 and 2020). This means that teachers are increasingly turning to such tools when teaching their subjects.

1 INTRODUCTION

The Law of Ukraine “On Education” states that the formation of information and communication competence in students is mandatory (Verkhovna Rada of Ukraine, 2017) because digital competence is recognized by European Union as one of the key competencies (Moiseienko et al., 2020). As a result, as stated in the conceptual framework of the digitalization of Ukraine, target audiences in the implementation of the state program on digital literacy are an elementary school, secondary school, vocational school, and higher education institutions (HEI) (HiTECH-office, 2016).

The use of digital technology in various fields of education today is one of the most important trends in the educational process in the world (Hlushak et al., 2020; Leshchenko et al., 2020; Ovcharuk et al., 2020; Pinchuk et al., 2019). Such technologies allow making the learning process more qualitative and interesting because using the media and interactive tools the teacher can introducing the different methods of working in the classroom: project method, research and development work, educational games, etc. (Demirbilek and Koç, 2019; HiTECH-office, 2016; Tokarieva et al., 2019).

Also, the latest situation with the pandemic spread of COVID-19 and corresponding measures that cause disruptions in the educational process around the world one more time emphasizes the importance of ICT in Education.

The issues of computerization and informatization of the educational process are widely consid-

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ered in (Bondarenko et al., 2020; Bykov et al., 2001, 1994; Chorna et al., 2019; Fedorenko et al., 2019; Iatsyshyn et al., 2020; Lavrentieva et al., 2020; Mintii and Soloviev, 2018; Nechypurenko et al., 2020; Popel et al., 2017; Rakov et al., 2009; Rashevska and Soloviev, 2018; Seidametova, 2020; Spivakovsky et al., 2019; Striuk et al., 2018; Talyzina, 1974; Trius et al., 2004; Zhaldak and Franchuk, 2021).

Also, the issue of the introduction of various ICT in the educational process of educational institutions is considered by foreign scientists.

In particular, Shakeabubakor et al. (Shakeabubakor et al., 2014) considering cloud computing services and applications to improve the productivity of university researchers.

Almerich et al. (Almerich et al., 2016), Kuzminska et al. (Kuzminska et al., 2019) analyzed teachers' information and communication technology competences. The use of cloud computing in higher education is considered in (Bansal et al., 2012; Biswas, 2011; Britto, 2012; Dineva and Nedeva, 2012; Ercan, 2010).

Dzikite et al. (Dzikite et al., 2017) investigated lecturers' competencies in ICT for effective implementation of ICT-integrated teaching and learning in textiles and clothing degree programs. Hanson-Baldauf and Hughes (Hanson-Baldauf and Hughes, 2009) reveal issues in the information and communication technology competencies of students enrolled in school library media certification programs. Kaplan and Haenlein (Kaplan and Haenlein, 2016) analyze the problem of higher education and the digital revolution.

The *purpose* of this article is to establish the current state of implementation of ICT in the educational process of institutions of general secondary education in Ukraine in 2019 and 2020 years.

2 RESEARCH METHODS

To find out the current state of implementation of various ICT in the educational process of institutions of general secondary education, as well as to form a group of selective disciplines, a survey of students of the first year of the Zhytomyr Polytechnic State University was conducted. In total, 167 respondents participated in the survey in the 2019 year, and 214 respondents in the 2020 year.

Students were asked to answer the following questions (Vakaliuk, 2019):

1. Do you know what application packages are?
2. Did you study application packages at school/college?
3. What kind of application packages have you studied/reviewed?
4. From which package did you study office application packages (text editors; spreadsheets; database management systems; demo tools)?
5. Do you know what “cloud services” is?
6. Which of the following programs and services is cloud-based?
7. Do you know what massive open online courses are?
8. Do you use these courses at school/college?
9. If the answer to the previous question is “Yes”, which one?
10. Have you used massive open online courses for self-study?
11. Did teachers use any other tools when studying programming in Computer Science?
12. If the answer to the previous question is “Yes”, what are the tools?
13. Did any information and communication technology tools (curricula, multimedia, simulators, games, virtual laboratories, etc.) be used in the school/college by non-CS teachers?
14. If the answer to the previous question is “Yes”, in what lessons did the teachers use such tools?
15. Which one did you enjoy the most and why (also indicate the item on which it was used)?
16. Was the teaching of this subject more interesting using a variety of tools than without using them?
17. What additional services would you like to consider and explore how to use them?

3 RESULTS

Let us analyze the answers to each question. First question “Do you know what application packages are?” the purpose was to establish whether the first-year students have basic concepts of the school course in Computer Science (CS). The results of the survey indicate that 91% of students have basic concepts, 9% do not in the 2019 year, and 2020 year – 87,4% of students have basic concepts, 12,6% do not (figure 1).

Regarding the second question, “Did you study application packages at school/college?”, in the 2019 year 18% said no and 82% said yes, and in the 2020 year 21% said no and 79% said yes (figure 2). This indicates that either the teacher did not adhere to the standard of general education, or the first-year students do not understand the basic concepts of CS.

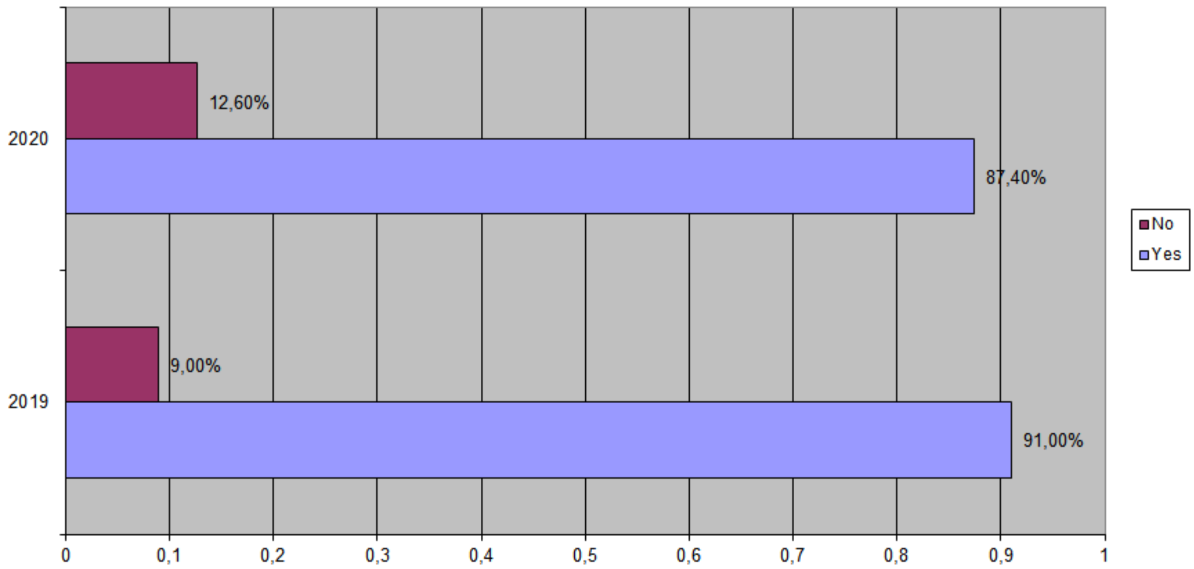

Figure 1: Percentage of answers to question # 1 “Do you know what application packages are?” (comparison of 2019 and 2020).

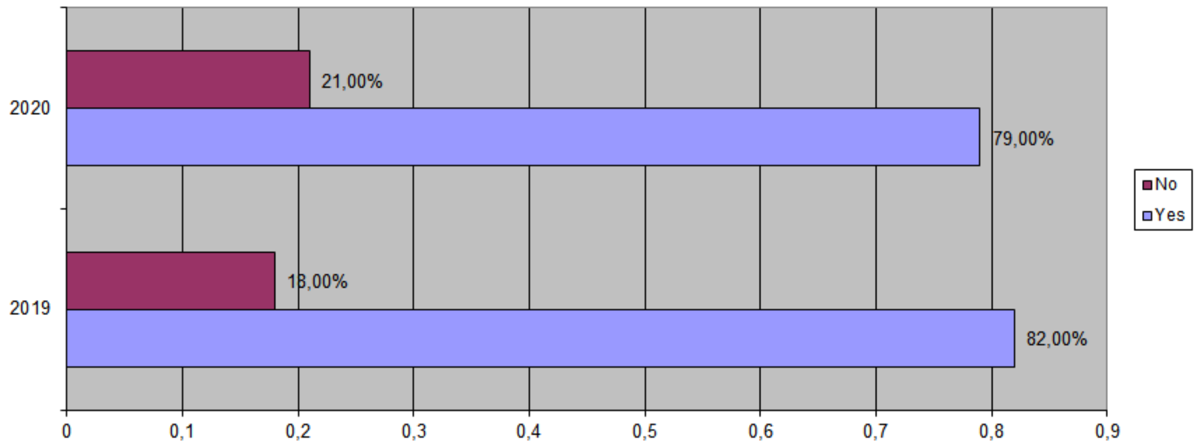

Figure 2: Percentage of answers to question # 2 “Did you study application packages at school/college?” (comparison of 2019 and 2020).

The answer to what exactly served as this distribution of answers to the previous question is to analyze the answers to the following. In response to the question “What kind of application packages have you studied/reviewed?”, all 167 respondents in the 2019 year and in the 2020 year – all 214 chose least one of the suggested options, which means that as a student they studied everything they needed, they just did not have the necessary terminology. In this case, in the 2019 year, 88% of respondents noted that they studied text editors, 77,8% – spreadsheets, 65,3% – tools for creating demonstration material, 38,3% – database management systems, 32,3% – graphic editors, 22,2% – educational programs, 16,8% – multimedia systems and computer games (figure 3). And in the 2020 year, 93,9% of respondents noted that they studied text editors, 84,6% – spreadsheets, 74,3% – tools for creating demonstration material, 38,3% – database management systems, 51,4% – graphic editors, 23,4% – educational programs, 27,1% – multimedia systems and computer games (figure 3).

During the informatization of society, new ICT are constantly appearing, which are replacing the usual applications. One of such ICT is cloud technology – a service that allows remote use of data processing and storage tools.

The next question was to find out whether schools use the standard MS Office suite, or whether some teachers use cloud services. Results of the answers to the question “From which package did you study of-

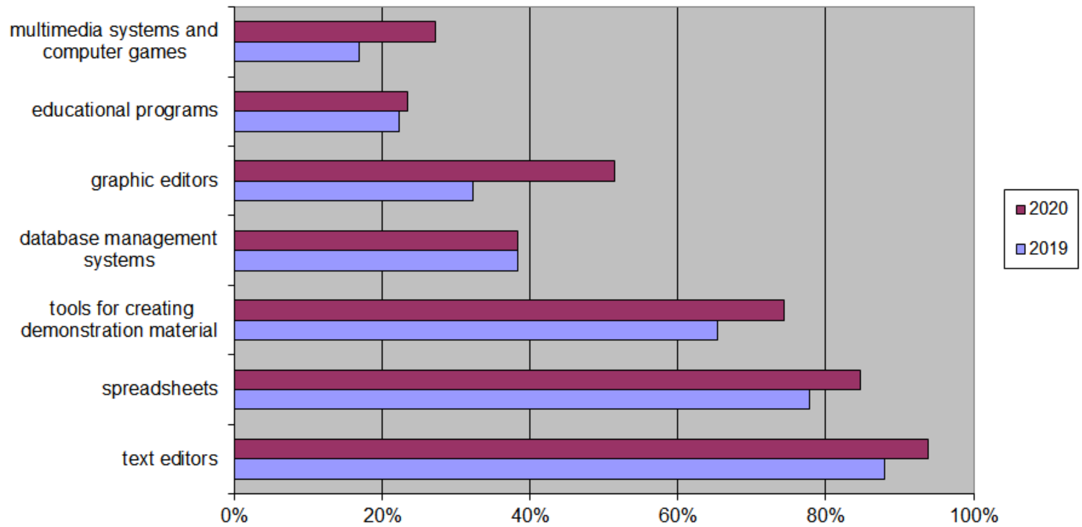

Figure 3: Percentage of respondents' answers to question # 3 "What kind of application packages have you studied/reviewed?" (comparison of 2019 and 2020).

fice application packages (text editors; spreadsheets; database management systems; demo tools)?" in the 2019 year are: 80,2% of those surveyed had studied MS Office, 22,2% had studied Office 365, and 24% had studied Google services, and in the 2020 year: 79,4% of those surveyed had studied MS Office, 28% had studied Office 365, and 31,3% had studied Google services (figure 4). In particular, 59,3% (99 people) in the 2019 year and 51,9% (111 people) in the 2020 year of the proposed list chose MS Office only. It is worth noting that in 2020 there were isolated cases of choosing the WPS Office.

That is why the next question was "Do you know what "cloud services" is?", to which 84,3% answered "yes" and the other 15,7% answered "no" in 2019, and in the 2020 year 88,3% answered "yes" and the other 11,7% answered "no" (figure 5). Although the study of cloud services is also included in the CS curriculum, not all school teachers adhere to the relevant document.

Answers to the following question "Which of the following programs and services is cloud-based?" are quite interesting as in the 2019 year 13,4% of respondents said that MS Office is a cloud service, and in the 2020 year – 7,5% gave the same answer. Also in 2019, 12,7% said Office 365 was cloud-based, 82,6% noted Google services, and 7,6% noted Prezi, and in the 2020 year 20,4% noted that Office 365 was cloud-based, 86,1% chose Google services, and 16,9% selected Prezi (figure 6). It's worth noting that Office 365, Google, and Prezi are among the cloud ones listed. The positive dynamics in the correct answers indicate that since 2020, graduates have met in the school curriculum with cloud services more often than graduates of 2019.

As Zhytomyr Polytechnic State University actively introduces massive open online courses, the following question "Do you know what massive open online courses are?". The survey results in the 2019 year indicate that 74,3% know what it is, the other 25,7% do not, and in the 2020 year – 78% know what it is, the other 22% do not (figure 7).

In doing so, in response to the question "Do you use these courses at school/college?" in the 2019 year 88,6% of students (percent of those who answered "yes" to the previous question) answered, "yes", and in the 2020 year – 92,5% (figure 8).

To find out what kind of open online courses are used in the educational process of general secondary education institutions, the following question was analyzed: "If the answer to the previous question is "Yes", which one?". The analysis of the results shows that in most cases 50% in the 2019 year are Cisco Academy courses, but in the 2020 year, this indicator is 23,8%. In some cases (13,6% in the 2019 year and 28,6% in the 2020 year) are Prometheus, and all others are isolated cases of other courses. It should be noted that Zhytomyr Polytechnic is closely cooperating with Cisco Academy, as a result of cooperation in the institution of higher education actively used courses of the said academy in the educational process (when studying courses "Computer Networks", "Python Programming", "Cybersecurity").

Also, to facilitate the use of massive open online courses (MOOC) in students' independent work, the following question "Have you used massive open on-

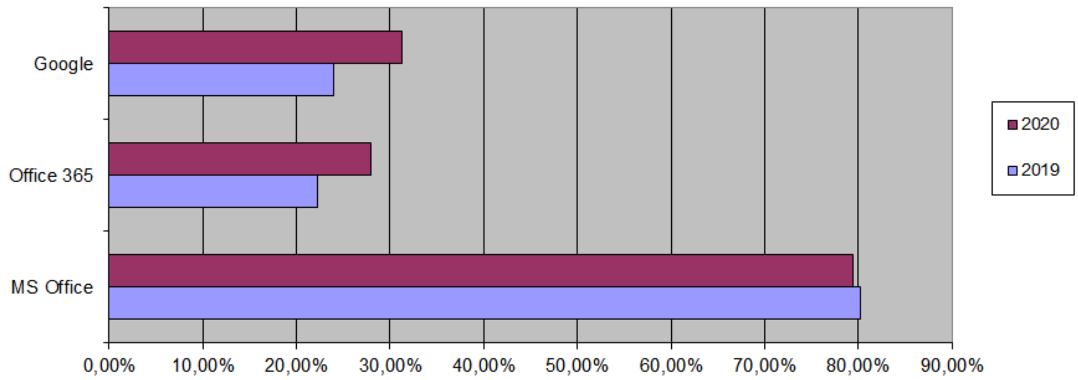

Figure 4: Percentage of respondents' answers to question # 4 "From which package did you study office application packages (text editors; spreadsheets; database management systems; demo tools)?" (comparison of 2019 and 2020).

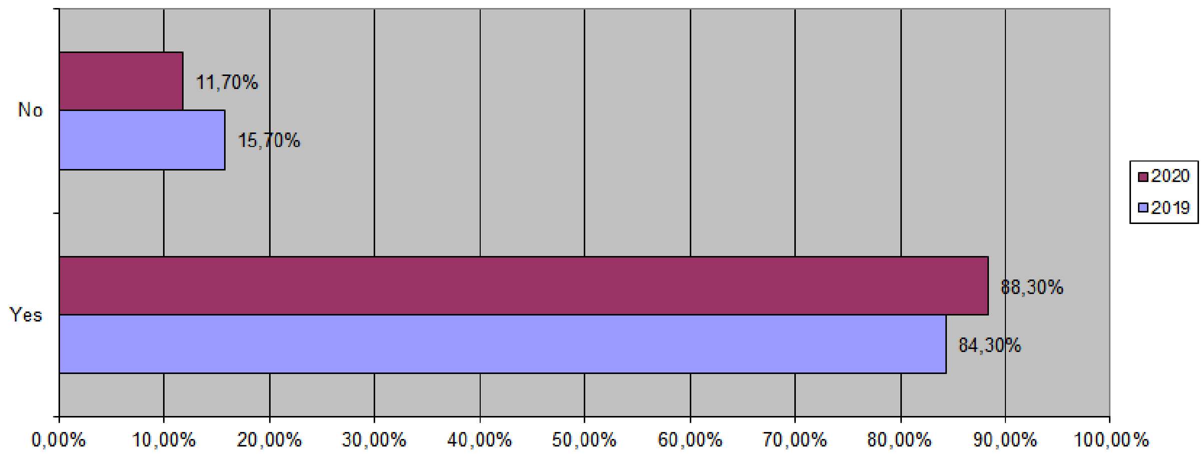

Figure 5: Percentage of respondents' answers to question # 5 "Do you know what "cloud services" is?" (comparison of 2019 and 2020).

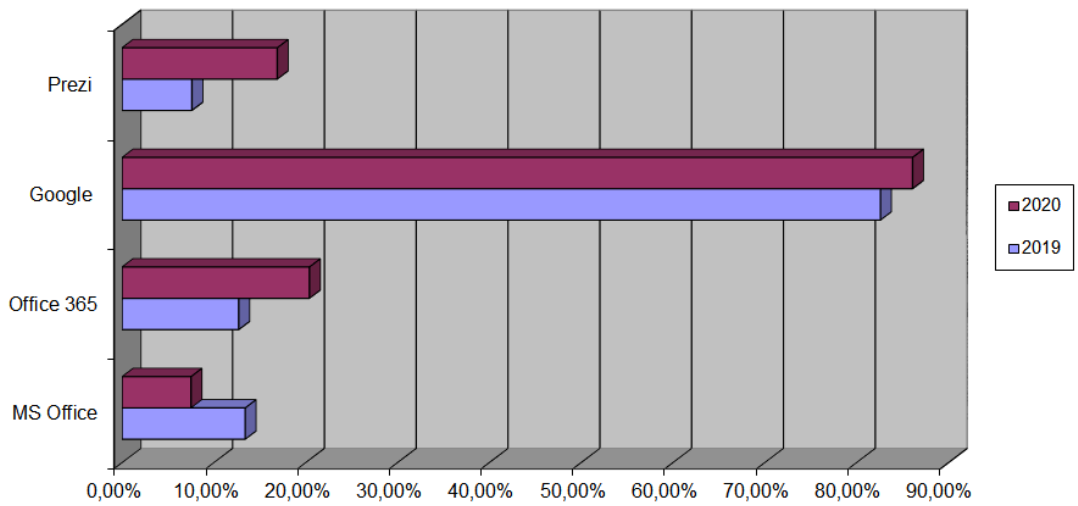

Figure 6: Percentage of respondents' answers to question # 6 "Which of the following programs and services is cloud-based?" (comparison of 2019 and 2020).

line courses for self-study?". The results of the survey (in the 2019 year – 67,1% – yes, 32,9% – no, in the 2020 year – 74,1% – yes, 25,9% – no, see figure 9) indicate that not all students used MOOC for indepen-

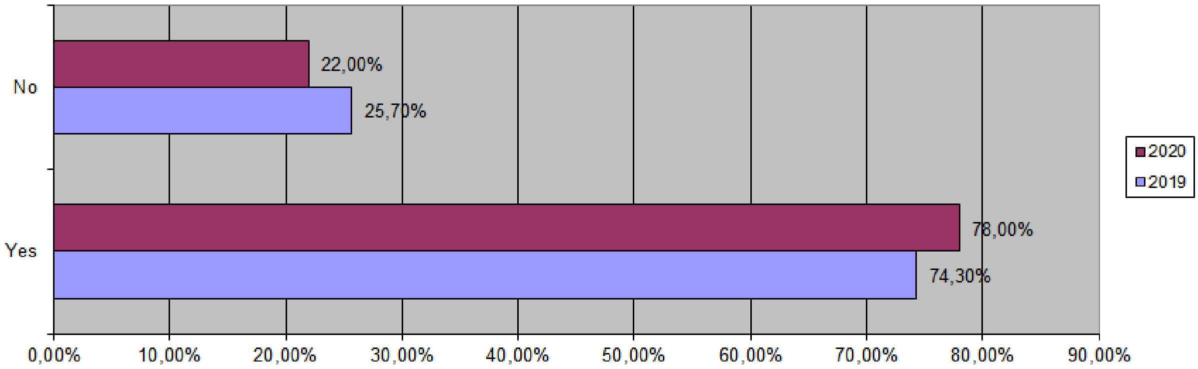

Figure 7: Percentage of respondents' answers to question # 7 "Do you know what massive open online courses are?" (comparison of 2019 and 2020).

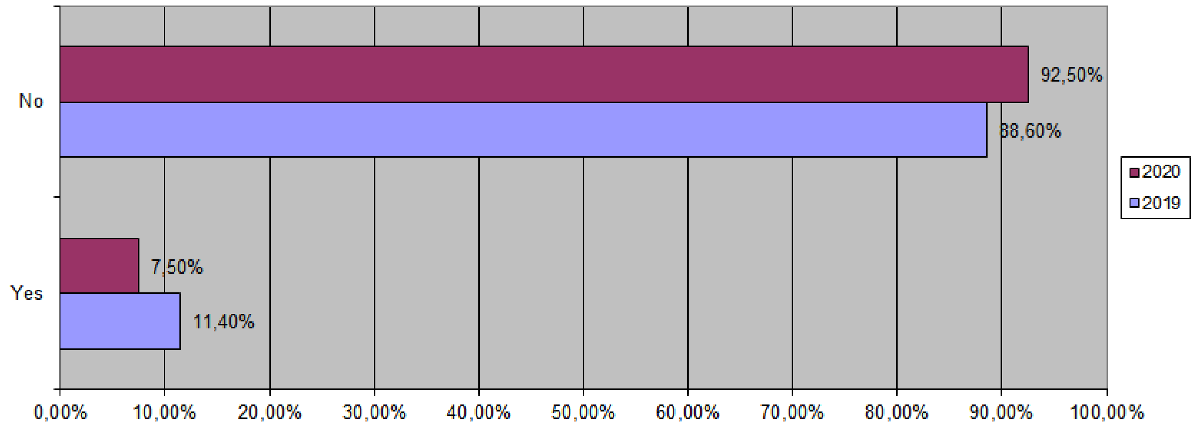

Figure 8: Percentage of respondents' answers to question # 8 "Do you use these courses at school/college?" (comparison of 2019 and 2020).

dent work, and therefore, before using these courses, it is worth conducting coaching for students who do not know how to use such MOOC.

Also, an important question was, "Did teachers use any other tools when studying programming in Computer Science?", in which 49,1% said "yes, they used", 50,9% – no in the 2019 year, and 51,9% said "yes, they used", 48,1% – no in the 2020 year (figure 10).

To find out what kind of tools were still used in CS lessons, the following question was asked: "If the answer to the previous question is "Yes", what are the tools?". The results (figure 11) indicate that in the 2019 year 32,2% of the respondents worked with online compilers, and in the 2020 year, this indicator is 21,6%, 33,3% in 2019, and 34,5% in the 2020 year with automated programming tasks, 50,6% in 2019 and 58,6% in the 2002 year – with simulators, 52,9% in 2019 and 53,4% in 2020 – with training games. According to previous research (Vakaliuk et al., 2020), it is with online compilers and automated systems for checking programming tasks that computer teachers want to work on in the educational process, but for some reason, they are not used yet. However, as can be seen from the studies of 2019 and 2020, teachers are beginning to use simulators more often in their work.

As ICTs can be used not only in CS lessons, the next question was "Did any information and communication technology tools (curricula, multimedia, simulators, games, virtual laboratories, etc.) be used in the school/college by non-CS teachers?".

Survey results indicate that in 48,5% in the 2019 year and 50,9% in the 2020 year of cases ICT was used in other lessons, in 51,5% in the 2019 year and 49,1% in the 2020 year it was not (figure 12). This shows that even the conditions created for non-CS teachers through quarantine do not contribute to the development of their competence in the use of ICT.

Among those who answered "yes" to the following question "If the answer to the previous question is "Yes", in what lessons did the teachers use such tools?" were distributed as follows (figure 13): 50% in 2019 and 49,1% in 2020 – ICT used in language

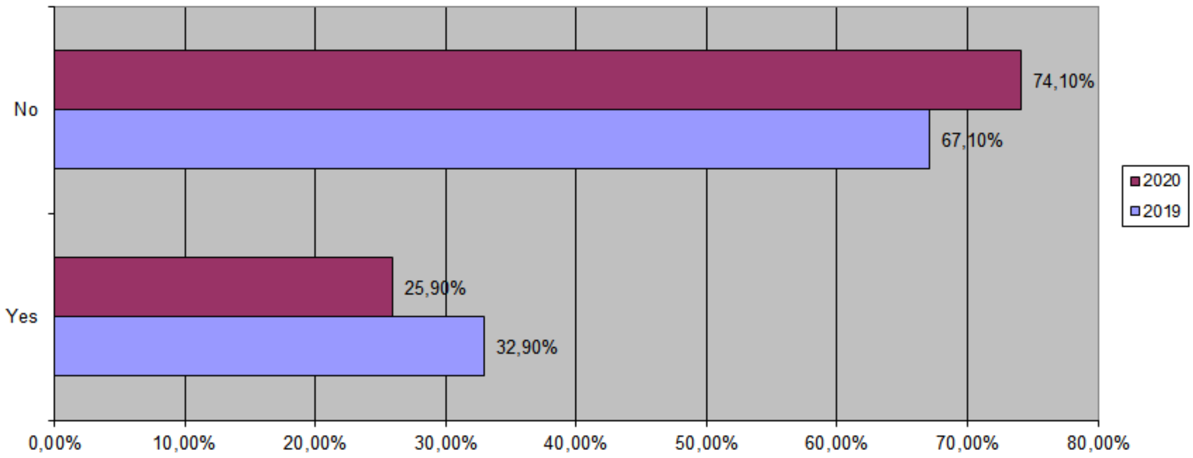

Figure 9: Percentage of respondents' answers to question # 10 "Have you used massive open online courses for self-study?" (comparison of 2019 and 2020).

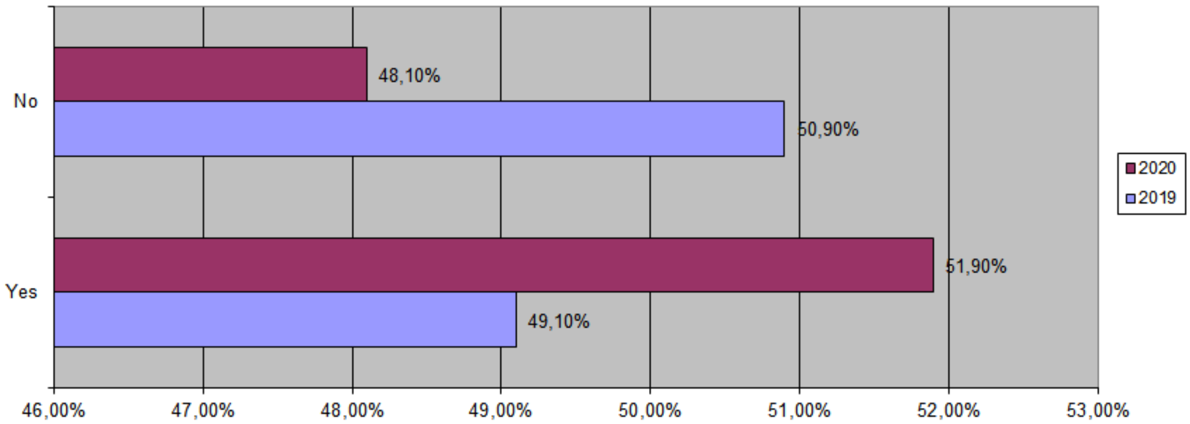

Figure 10: Percentage of respondents' answers to question # 11 "Did teachers use any other tools when studying programming in Computer Science?" (comparison of 2019 and 2020).

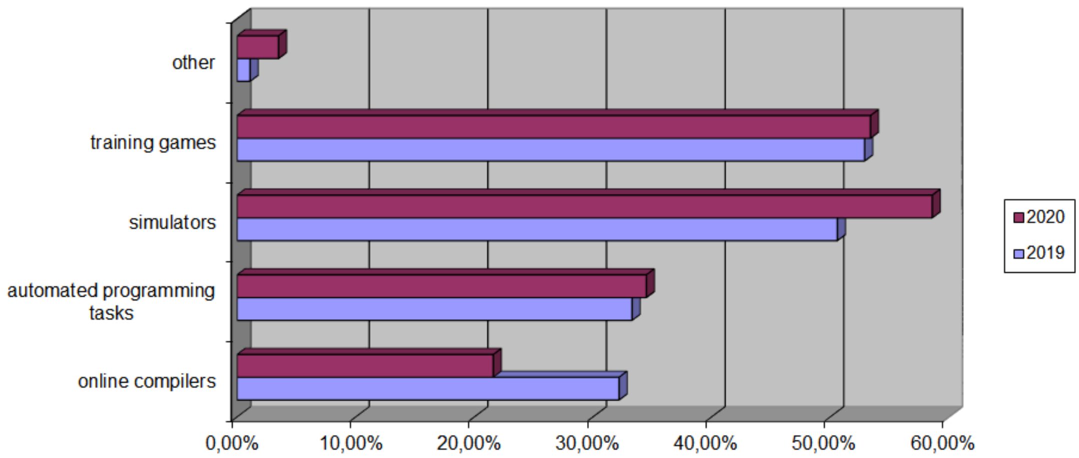

Figure 11: Percentage of respondents' answers to question # 12 "If the answer to the previous question is "Yes", what are the tools?" (comparison of 2019 and 2020).

and literature lessons; 48,8% in 2019 and 48,2% in 2020 – in mathematics lessons; 43,8% in 2019 and 57,3% in 2020 – physics; 38,8% in 2019 and 27,3% in 2020 – history; 33,8% in 2019 and 39,1% in 2020 –

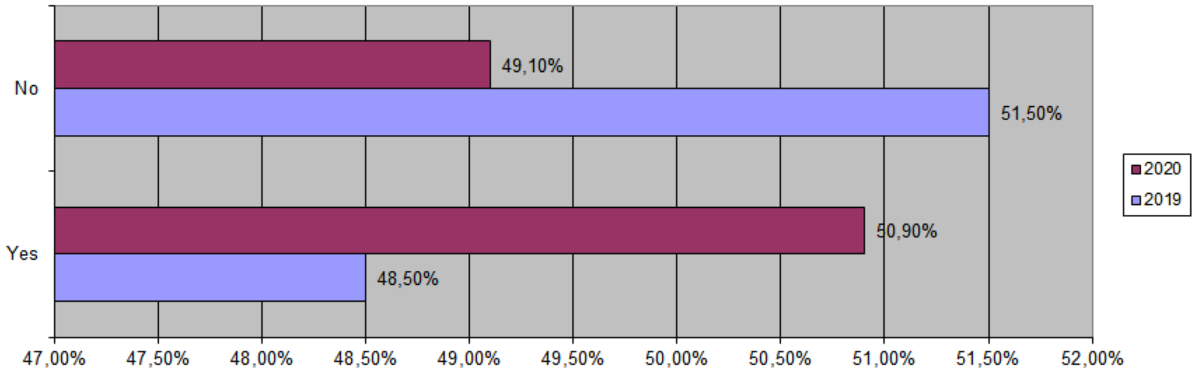

Figure 12: Percentage of respondents' answers to question # 13 "Did any information and communication technology tools (curricula, multimedia, simulators, games, virtual laboratories, etc.) be used in the school/college by non-CS teachers?" (comparison of 2019 and 2020).

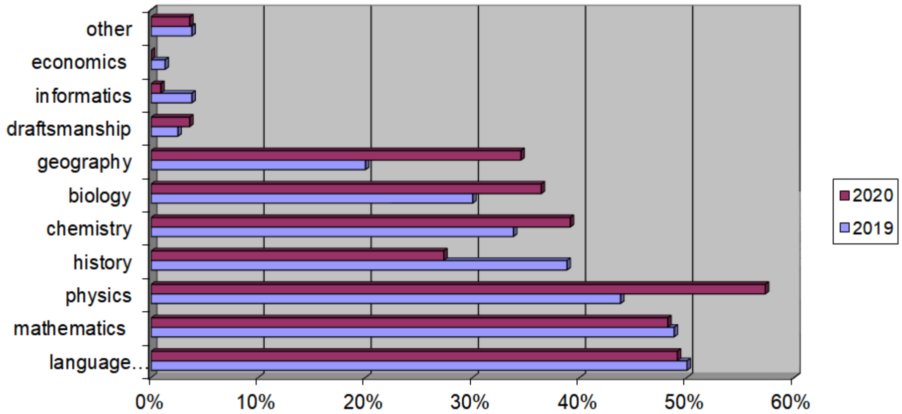

Figure 13: Percentage of respondents' answers to question # 14 "If the answer to the previous question is "Yes", in what lessons did the teachers use such tools?" (comparison of 2019 and 2020).

chemistry; 30% in 2019 and 36,4% in 2020 – biology; 20% in 2019 and 34,5% in 2020 – geography, etc.

This indicates that most teachers still do not use different ICTs in their activities, although there are currently many tools that can be used in the educational process of a general secondary education institution.

The next question is, "Which one did you enjoy the most and why (also indicate the item on which it was used)?" made it possible for teachers to use the following ICT tools in their activities: multimedia, presentations, games, documentary, online quiz, educational films, simulators, and automated verification systems.

Analysis of the distribution of answers to the question "Was the teaching of this subject more interesting using a variety of tools than without using them?" (figure 14) indicate that it is still more interesting for students to use ICT in the educational process than not use in both cases.

To determine what other services could be considered with students, the answers to the question "What additional services would you like to consider and explore how to use them?" were analyzed. The results show that students want to study game simulators in detail – 62,3% (2019) and 57,5% (2020), cloud services for collaboration on documents – 59,9% (2019) and 65% (2020), educational games – 45,5% (2019) and 41,6% (2020), tools for learning programming – 43,7% (2019) and 60,3% (2020), simulators – 41,3% (2019) and 80% (2020), computer network modeling tools – 35,3% (2019) and 53,7% (2020), virtual labs – 34,7% (2019) and 37,9% (2020), massive open online courses – 29,9% (2019) and 33,6% (2020), statistical data processing tools – 25,7% (2019) and 34,1% (2020), cloud services to build distance courses – 24,6% (2019) and 35,5% (2020), collaboration tools for project activity – 23,4% (2019) and 41,6% (2020), mathematical services – 22,8% (2019) and 30,8% (2020), mind maps – 19,8% (2019) and 24,8% (2020) (figure 15). This indicates that computer science teachers are increasingly using different ICT tools in

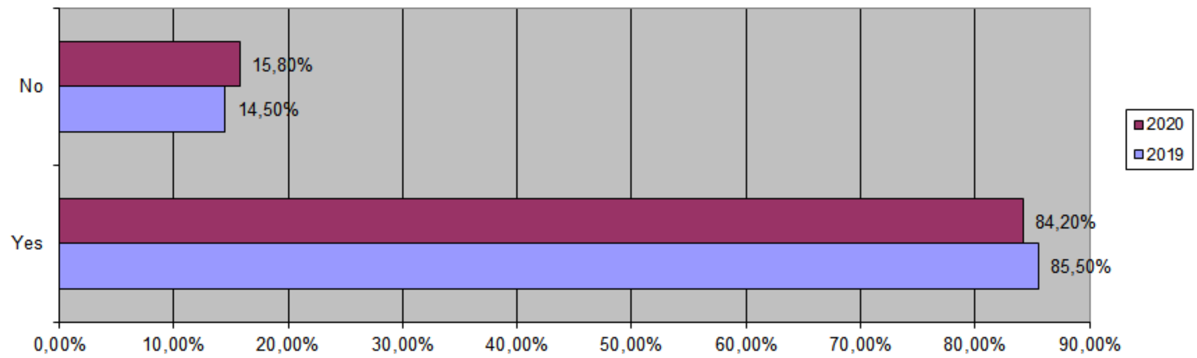

Figure 14: Percentage of respondents' answers to question # 16 "Was the teaching of this subject more interesting using a variety of tools than without using them?" (comparison of 2019 and 2020).

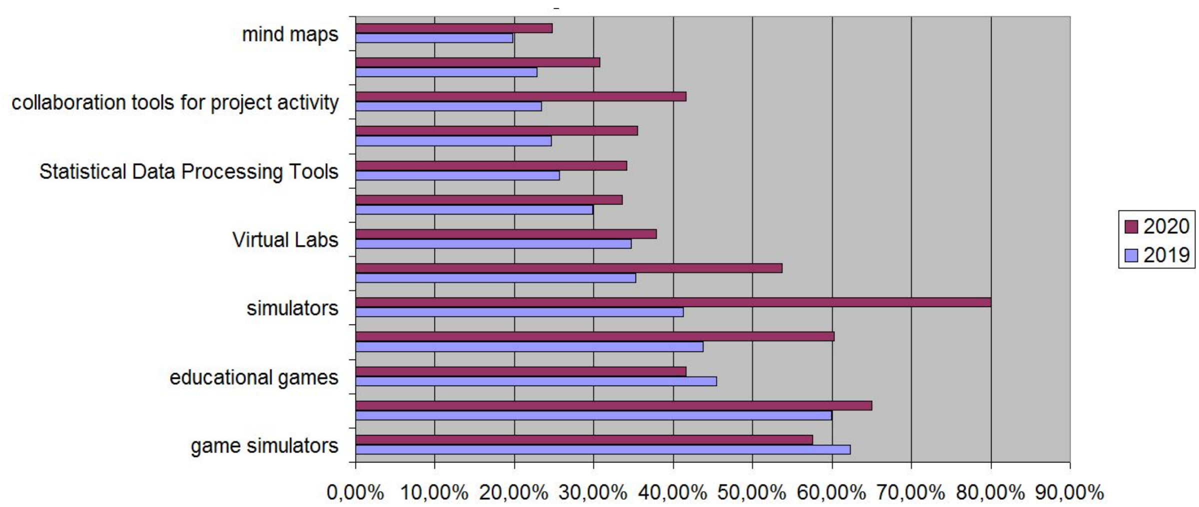

Figure 15: Percentage of respondents' answers to question # 17 "What additional services would you like to consider and explore how to use them?" (comparison of 2019 and 2020).

the learning process.

4 DISCUSSION

Besides, the course "Application Packages" for specialties 121 "Software Engineering", 122 "Computer Science", 123 "Computer Engineering", 125 "Cybersecurity" and 126 "Information Systems and Technologies" at the Zhytomyr Polytechnic State University has been expanded for study some cloud services that can serve as an alternative to the usual MS Office.

As a result of the research, the introduction of the discipline "Educational technologies and digital education" into the training of future information technology specialists was substantiated (Vakaliuk et al., 2019a), and the certification program "Information systems and cloud technologies in the educational process" was developed (Vakaliuk et al., 2019b), which is aimed at teachers of general schools, teachers of HEI, specialists in the field of additional educational services, and other specialists.

Certified educational program "Information Systems and Cloud Technologies in the Educational Process" aims at forming knowledge about the peculiarities of using information systems and cloud technologies in the educational process of educational institutions, forming the ability to plan, develop courses at the methodological and information-technical levels using modern information systems and cloud technologies, to organize various forms of higher education by applying modern information systems and cloud technologies.

As a result, the "Cloud Technologies in Distance Learning in Quarantine" course was launched in several waves during 2020, aimed at raising teachers awareness of various IT and learning tools.

5 CONCLUSION

In conclusion, we can conclude that the positive dynamics of the use of various ICT tools in the educational process are present (compared to school graduates in 2019 and 2020).

In this case, the positive dynamics mean that compared to the previous year, more and more teachers are increasingly turning to various ICT and relevant services, tools, teaching their subjects. This, in turn, promotes students' interest in studying a subject.

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Trends in the Development of e-Learning for Civil Servants

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Abstract: The article generalizes the information on numerous components of the system of public servants' lifelong education. One of the key areas of public administration development is the development of e-government, so e-learning is considered as an important means of preparing public servants to implement this task. The domestic and world experience of e-learning of public servants, which is realized in the form of distance education, mixed learning and as a component of the traditional classroom educational process, is analyzed. The threats and benefits of ICT training, based on the survey of civil servants trained in ICT in Ukrainian higher educational institutions are highlighted. The trends in the development of e-learning have been identified on the basis of scientific and empirical facts. These trends are more or less inherent in some countries, that is why these countries can determine the current challenges of e-learning development.

1 INTRODUCTION

Digitalization has covered all spheres of life in modern society (Kucherova et al., 2020). The introduction of information and communication technologies (ICT) has become one of the main trends in public administration. The spread of e-government allows bringing government closer to citizens, promotes such values as openness, transparency, accountability and public access to information, which improves the quality of public services (Trcek, 2019). In the context of digitalization of society and the challenges of modernity (pandemic COVID-19 (Tkachuk et al., 2021)), the importance of civil servants' e-learning and e-government is growing both in the traditional provision of digital services and in new innovative efforts to overcome the crisis. At the same time, public authorities are facing challenges of disseminating false information, declining trust in government institutions and increasing skepticism, making it difficult to reach consensus in society, and numerous forms of digital gaps, especially among the poorest and the most vulnerable groups of citizens. In this situation, as noted in the OECD, civil servants must adapt to new requirements, such as transparency of administrative decisions, the right to appeal, data protection, providing information to citizens, the operation of hotlines (OECD, 1997).

Nowadays, information and communication technologies allow to solve a set of tasks related to the collection, processing, storage and distribution of graphic, textual, digital, audio and video information based on electronic means of computer technology and communication in the interests of its users. These tasks cover almost all activities of a public servant. As a result, there is an urgent need for special training of civil servants in e-government, which can be implemented through the introduction of e-learning.

NASPAA STANDARDS focuses on the critical situation in the formation of civil servants competencies because they need skills to succeed in a multisectoral, reference and rapidly changing environment (NASPAA, 2020).

Since 2001, the UN has conducted annual surveys of 193 member countries on the development of digital government, which confirms the importance of digitalization of public administration and equalization of development in this regard. An important role

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in achieving this ambitious goal is played by training civil servants in the basics of e-government (United Nations, 2020).

One of the key areas of public administration development is the development of e-government, so e-learning can be considered as an important means of preparing public servants to implement this task. The vast majority of civil servants study and work at the same time, so e-learning is more in line with the current situation, allows combining work and study. The content and means of public servants' activity is a constantly changing and evolving system, so e-learning can provide more flexible approach to responding to new tasks, challenges of public life. In this regard, it is important to identify general trends in e-learning for civil servants. These trends are already existent in the world but have not been approved in all countries. Indeed, for some countries, these trends are already common practice. However, each country has specific features that are important to highlight, which will help create a general picture of the desired state of e-learning for civil servants.

2 METHODOLOGY OF THE RESEARCH

The results of the study presented in the article were obtained using a set of methods. Identification of trends in the development of e-learning of civil servants was carried out on the basis of analysis and generalization of leading experience, modern approaches and requirements for e-learning of civil servants, the study of opinions of civil servants who study with the use of ICT technologies. Information from both the world's largest and most developed countries and developing countries was considered. The source base of the study consisted of 3 groups of sources. The first group of sources was studied by the netnographic method: sites of different countries institutions engaged in training of civil servants, sites of accreditation institutions, international associations and organizations related to public administration.

The second group of sources, which was analyzed during the study, consisted of scientific publications on the use of information technology in the training of civil servants. The third group of sources consisted of international organizations documents that deal with the problems of civil service and training of civil servants.

The analysis of world experience served us to identify general trends in civil servants' e-learning, which are existent in the world, but have not been approved in all countries. Selected trends allow any country to analyze their practice and determine what needs to be changed. Unlike many other countries, the experience of civil servants' training in Ukraine is short. The world experience should be adapted to Ukrainian realities; the peculiarities of the national education system, the needs of Ukrainian civil servants, etc. should be taken into account. The use and effectiveness of E-technologies depend significantly on students, it is important for us to clarify the position of students to develop the use and effectiveness of it. That is why an experimental part of the study was conducted: to study the opinions of civil servants who study ICT in Ukraine, namely: how they perceive this approach to learning, how ready they are for this form of learning and how they assess it, what are their needs in connection with the digitalization of public service.

Empirical material on the impact of ICT on the civil servants' training in the domestic education system was obtained during a survey of 285 graduate students in "Public Administration and Administration" (distance study) in Luhansk and Ivano-Frankivsk regions, the vast majority of students work in public administration. Respondents assessed their own readiness to use ICT in the educational process and in their self-development, as well as the effectiveness of e-government and digitalization of public administration in general. The Delphi method was used to identify the benefits and threats of using ICT in the educational process. At the first stage the lists of advantages and threats of e-learning based on the results of a survey of 285 masters in the specialty "Public Administration", analysis of scientific literature, generalization of e-learning experience were determined. At the second stage these lists were evaluated on a 10-point scale by a group of experts, which consisted of 48 undergraduates of the 1-2 courses in the specialty "Public Administration". The results of the experimental work were confirmed by statistical analysis. This material was taken into account when identifying trends in the development of e-learning for civil servants; it was also correlated with identified trends and it emphasized the importance of implementing these trends in the Ukrainian education system for civil servants.

3 LITERATURE REVIEW

Problems of training of civil servants, use of ICT were investigated by: Dobos (Dobos, 2015) (learning environments in civil service professional development training), Clark and Pal (Clark and Pal, 2011) (analysis of academic programs and professional competencies in Canada), He (He, 1702) (training system of civil servants in China and Australia), Ishikawa (Ishikawa, 2007) (training of Japanese local government officials), Suleimenova (Suleimenova, 2016) (civil service training in Kazakhstan), Green and Hogarth (Green and Hogarth, 2016) (alignment of public policy and employer views for training provision), Sarantis and Ben Dhaou (Sarantis and Ben Dhaou, 2018) (training needs on Electronic Governance), Kim (Kim, 2016) (innovating training), Maniam (Maniam, 2011) (preparing public officers for new modes of governance), Saini (Saini, 2020) (considered 5 e-government trends that dominated in 2020, as well as forecasts that provide standards in 2021), Bezhovski and Poorani (Bezhovski and Poorani, 2016) (the evolution of E-Learning and new trends), Gaur (Gaur, 2015) (research trends in E-Learning), Carabaneanu et al. (Carabaneanu et al., 2006) (trends in E-lerning), Çağatay Baz (Çağatay Baz, 2018) (new trends in E-Learning), Valverde-Berrocoso et al. (Valverde-Berrocoso et al., 2020) (trends in educational research about E-Learning).

The documents of international organizations, accreditation agencies and associations contain various information on the civil servants training. But so far there are no publications that summarize the characteristics of e-learning of civil servants in the world. The problem of development of civil servants' e-learning trends has not been covered in publications yet.

The *purpose* of this article is to identify trends in the development of e-learning for civil servants, aimed at forming their professional competencies which should provide effective e-government.

4 ANALYSIS OF THE WORLD EXPERIENCE OF CIVIL SERVANTS' TRAINING FOR E-GOVERNMENT THROUGH E-LEARNING

There are two directions in the system of civil servants e-learning in the world. The first one is the use of ICT as a means, technology of training organization. The second one is the study of ICT as a means of e-government, which culminates in a master's degree or certificate.

It is no coincidence that the framework of competencies of civil servants (assets.publishing.service.gov.uk, 2018) contains such competencies as: Government IT Profession, Government Knowledge, Information Management Profession. This necessitates the use of ICT not only as a learning technology, but also the content of education, which provides civil servants training for using these technologies in public administration.

Nowadays, to ensure e-government, specialists in the development of e-government development strategy, system administrators of IT support, electronic data processing, automation of management functions, decision support, creation of e-office, expert support of e-government development projects, project managers are needed. development of e-government. These tasks are implemented mainly by master's programs. There are many universities in the world that offer master's degrees in public administration (Ashford University, Capella University, Kaplan University, Texas A&M University – College Station, Villanova University, George Washington University, North Central University, Syracuse University, University of Houston, Seton Hall University, Rutgers University, University of Central Florida, University of Nebraska Omaha, San Diego State University, University of Baltimore, Old Dominion University – Norfolk, University of North Carolina, University of Southern California, Colorado State University, University of Colorado Denver and others). Most universities include e-government disciplines in their curricula. And some universities specialize in training civil servants for e-government. Consider a few of them.

University of Kent implements the MPA curriculum, which includes a mandatory course Public Sector IT Management (Kent State University, 2021). This course focuses on the management of information technology (IT) systems in public sector agencies. Specific topics covered include: planning and acquisition of hardware and software and networks, organizational governance and implementation, information security and privacy legal issues surrounding IT management, service delivery and emerging enterprise technologies.

Leiden University (Universiteit Leiden, 2021), the oldest university in the Netherlands, emphasizes that the public sector needs interdisciplinary expertise and professionals able to make the most of the potential of ICT and technological innovation. The specialist training program has a strong international focus.The program offers two specializations: ICT in business and ICT in the public sector.

Master programme organized by the KU Leuven, the University of Münster and Tallinn University of Technology, and co-financed by the European Union under the Erasmus+ programme (The Master of Science in Public Sector innovation and e-Governance (PIONEER)) (PIONEER, 2018) declares the mastery of the basics of the use of information systems in the public sector, as well as the introduction of e-government.

The University of Münster (www.uni-muenster.de, 2021) aimed at a deeper understanding of the use of information systems in relevant business processes, ICT projects, new approaches to service delivery, as well as an understanding of the possibilities of ICT for public administration.

Tallinn University of Technology offers Master's programme (Tallinn University of Technology, 2020). The Technology Governance and Digital Transformation. It equips students with the capacity for critical thinking and with practical management skills on technological change, innovation and digital transformation that will make it equips students succeed in tech-focused private and public organizations as well as in international bodies. Students gain to understand digital technologies as the key driver of development around the world, that digital transformation brings about sustainable, green growth and human-centred development. Students gain in-depth knowledge of the potential benefits, risks, factors of failure / success of e-government, the role of e-government in society and trends in innovation in the public sector.

At the University of Birmingham (University of Birmingham, 2021) the Master of Civil Service Training is provided by the Institute for Local Government Research (INLOGOV), which is the leading center for research and teaching on local government and strategic public administration in the UK. This ensures the unity of the process of training and research, which is a condition for improving the quality of the process of civil servants training to work at the national and international levels. According to the university, 62% of students study at a distance form – they are representatives of other countries.

The analysis of training programs for civil servants allows us to draw several conclusions:

- the e-learning program creates favorable conditions for cross-cultural interaction of students and teachers, which significantly enriches the learning process;
- the number of students from other countries is an indicator of the quality of master's training at the world's leading universities;
- the participation of representatives of different countries in master's programs is the evidence not only of globalization processes, but also the formation of global theory and practice of public administration, which has not yet received clear systemic coverage;
- online learning is an important factor in the quality of IPA masters training in terms of realizing the existing potential of e-learning;
- providing online training requires more resources, but allows to improve the quality of IPA training and make it available to representatives of different countries.

The functioning of e-learning of public servants in the world's leading universities has led to the formation of a new social phenomenon aimed at the development of public administration. This effect is provided by a combination of the processes of training and development of civil servants, research, the introduction of innovative technologies of public administration. The subjects of this process are scientists, teachers and civil servants – students who create social communities interested in the development of public administration as a requirement of social progress.

The development of e-learning of civil servants is influenced by the development of its technical and program capabilities, cooperation of specialists from different countries and Wiley Education Services, involvement of working civil servants in the training process, close connection with public administration practice.

E-learning programs are implemented by national administrative schools, academies, in some cases universities, banks, associations, and certain organizations, in China they are party schools. The result of completion these programmes is a certificate. In some countries special e-learning institutions have been established: the GDS Academy in the United Kingdom (GDS Academy, 2020), Design Academy for Public Policy in Argentina (LabGobAR, 2016), the Brazilian Distance Education Association ABED (ABED, 2021), DigitalGov (DigitalGov, 2020).

The GDS Academy inspired similar initiatives in Scotland and Canada, which launched its own Digital Academy under Canada's School of Public Service in January. So GDS declares as a goal to build digital capacity in government, through training civil servants in computer science, user-centric design, data, and other disciplines required.

In 2015 Singapore began offering government employees free access to over 2,500 classes, including many on an online platform Udemy, at the country's Civil Service College in July 2018. There are introductory sessions for non-specialists who want to learn the fundamentals of new tech and more advanced courses for civil servants who work in digital. As of February 2019, it has trained more than 10,000 employees at all levels of government.

Nowadays, Kazakhstan ranks 33rd in the UN e-government ranking , that is why the training of civil servants is focused on embedding programs that strengthen the ability of civil servants to use digital technologies and train IT professionals for all levels of government in the educational process. Nazarbayev University in Kazakhstan and the Academy of Public Administration under the President of the Republic of Kazakhstan train specialists in this area (Suleimenova, 2016).

In the vast majority of countries, institutions that train civil servants are short of funds. The need to save money leads to different approaches to solving this problem. For example, in Spain, austerity has made innovation in the civil service one of INAP's priorities, while in Canada, austerity has given new attention to e-learning.

Although classroom learning remains the main means of educating public servants today, it should be noted that there is an increase in online learning offers. For example, the Canada School of Public Service (CSPS) (Clark and Pal, 2011) offers nearly 400 self-study courses available online in a variety of administrative and policy areas, such as values and ethics, language learning and risk management. The Canada School of Public Service offers all public servants courses on a variety of topics. While many are held in conventional classrooms, others are online, interactive and self-paced, allowing for learning when it's most convenient.

E-learning is a key element of government training in the UK as well. Through civil service training, the country has been able to provide a high level of training for its staff, despite significant budget cuts.

The Australian Public Service Commission offers numerous e-learning courses that are implemented using different technologies. The APSC Curriculum Catalog (APSC, 2021) includes suggestions for those who are new to APS, those who want to build their core skills and those who are looking to further develop their leadership capabilities. The list of courses is growing every year, so it is natural that Australia is one of the world's leading countries in terms of e-government.

One of the leading centers for e-government is Hong Kong and it is not accidental. The Civil Service Training and Development Institute CSTDI (Hong Kong) (Civil Service Bureau, 2017) is constantly training civil servants to use ICT. It aims to help all civil servants acquire the basic knowledge and skills needed for the new digital age. For this purpose, a training portal on "Innovation. Technology" has been created, information on innovative trends in new technologies, modern equipment for information and communication technologies, project management of information technology implementation, Internet security and protection of personal data, tools for analysis large databases, methods of making infographics and video clips, etc. are downloaded constantly. In 2019, it was planned that about 43,000 civil servants at various levels would participate in information technology training programs organized by CSTDI.

Consider examples of certified training programs for civil servants. The 5-day training seminar "E-Government, Digital Government Transformation, Innovative Public Policy and Services" is planned by GLOMACS in Dubai (GLOMACS Training & Consultancy, 2021). This GLOMACS training seminar will cover: E-Government, Digital Transformation, Civic Centrism, Innovative Public Policy and Services, Language Comprehension. This interactive course involves a mix of presentations with discussions, case studies, role-plays, discussions and exercises, including case studies. Visitors will provide questions and examples from their own work environment. As in other courses, the Zoe Talent Solutions model is used, which provides four steps Do – Review – Learn – Apply Model.

Upon successful completion of this training course, participants will be awarded a GLOMACS certificate with appropriate credits for continuing professional education.

In the GDS Academy Digital leadership course engages non DDaT (digital, data and technology) For senior civil servants in central government who need to support digital transformation and oversee joined-up, trusted services which respond to user needs. The course content is policy and data based and is validated by senior members of the digital, data and technology (DDaT) profession across 30 government organisations. Case studies and examples are exclusively public sector. These facts indicate that the content of civil servants training in e-government is determined on the basis of the position of leaders of e-government implementation, which was studied and summarized by the training organizers (GDS Academy, 2020).

Another example: the themes of HAUS trainings (Training HAUS, 2021) support the objectives set by the government of Finland, and respond to changes in the operative environment. This is why our selection of training programmes and our course content are updated constantly. This courses are always up to date, of high quality and utilise a rich selection of teaching methods. Content available in the eOppiva digital learning environment for public administration is leveraged also in courses implemented in the form of contact teaching. The themes and methods of our training programs are designed in closed collaboration with key actors in public administration, including: The Administrative Unit of the Finnish Government.

The US's DigitalGov team also organises communities of practice in more than 20 digital disciplines, from AI to virtual reality.

DigitalGov University provide a range of free online and in-person trainings and events for people and teams across the federal government. Many of events highlight innovations, case studies, tools, and resources. All of events are recorded and archived on YouTube. Trainings are open to anyone working in the government or for a government agency (DigitalGov, 2020).

In Japan, the Japanese Academy of Municipal Personnel (JAMP) and Local Autonomy Colleges provide ongoing training in e-government and e-administration, information and communication technology for municipal staff, from high-level technicians to senior officials (Ishikawa, 2007).

From the point of view of socio-economic and political transformation in India, the task of training civil servants is to include project work, the use of information technology, which will improve the quality of public administration and access to it, establishing links with national and international institutions. In India, attention is drawn to the fact that, if mass learning is needed, there are distance learning schemes that will ensure the implementation of this task.

In India, the use of information technology is seen as a means of improving the quality of public administration and access to it. In this regard, educational institutions offer a variety of programs on the Internet that provide all the knowledge and skills needed for leadership in public administration. Working adults do not need to leave their careers to get a degree (Mishra, 2012).

E-learning is gaining momentum in Brazil. The Brazilian National School of Public Administration ENAP offers 26 free e-courses on the following topics: Ethics; State budget and finances; Human resource management; IT&C (information technology and communications); Procurement legislation, etc. (Stadler et al., 2017).

Civil servants in all parts of Brazil apply for ENAP courses (Stadler et al., 2017) because of the quality of their content and their relevance to their day-to-day activities. The ENAP policy allows The Brazilian National School to offer all e-learning courses free of charge, which means that the School provides from its own budget the design, development and review of these courses.The content of e-learning depends on the state of e-government in the country. For example, in Cameroon, the training of civil servants in IT primarily covered some software tools, such as Microsoft Word, Excel, PowerPoint, Publisher and the basics of using the Internet, basic office programs (MS office).

In Zimbabwe, the training of civil servants is aimed at providing specific skills important for the functioning of the civil service, as well as knowledge of how to use information technology (working with a word processor, spreadsheet, databases, graphics, multimedia systems) (World Bank, 2016). These programs can be divided according to the needs of civil servants: programs for those who have just entered the civil service are aimed at studying programs of permanent use – Microsoft Word, Excel, PowerPoint, Publisher and the basics of Internet use, basic office programs (MS office); programs dedicated to general problems of e-government; programs related to specific tasks and problems of e-government; programs on a variety of public administration issues in which e-learning is a learning technology. Most often, the civil servant himself, according to his needs, chooses a particular course and studies it. In some cases, civil servants are offered seminars that address a wide range of e-government issues. Such training can be both free and paid.

Electronic technologies are used by almost all educational institutions to control the quality of education. Thus, the French National School of Public Administration ENA, conducts assessment after graduation, receives information from the association of graduates of ENA. Graduates are not just former students of the school, but also employers or colleagues of new graduates. Their feedback also provides an understanding of whether the current profile and qualifications are relevant to the tasks to be performed and the challenges to be addressed in today's public administration. Annual surveys are conducted more formally and systematically on the basis of questionnaires sent to all graduates who have left ENA in the last 14 months and started working in the French public administration. A parallel questionnaire is sent to their supervisors in the ministries and departments where they work to find out whether the content of the training conducted at ENA meets the expectations and needs of the French government and whether former students feel they are well prepared to perform their duties. In some countries, such as Australia, 360-degree staff assessment (or circular assessment) is used to identify potential opportunities and learning outcomes (He, 1702).

In many countries, training of civil servants in the workplace is becoming more widespread, which is almost entirely based on the use of information technology, which ensures the implementation of organizational, control, and evaluation tasks. It is information technology that can turn the training of civil servants in the workplace into a managed process.

In China, e-communication is seen as a means of learning at work. The introduction of e-government is supported by the training of public servants. For example, in Yunnan Province, online trainings were conducted for civil servants from 53 departments. The e-Government portal of China provides information on online training for civil servants (Public Affaires Training, 2006).

The results of the study conducted by the OECD are important for the realization of the purpose of our work. Thus, according to the survey of civil servants, one of the five most important skills of a civil servant is information management and the use of new technologies, and schools are increasingly looking for new and innovative approaches to training civil servants, including the integration of information and communication technologies (ICT). However, only half of the respondents stated that they have a clear policy on the use of digital technologies for the training of current and future civil servants (OECD, 1997).

The analysis of the world experience of training civil servants for e-government by means of e-learning allows to systematize the existing trends in the modern educational space and to identify tools and means of e-learning that increase the readiness of public servants for e-government.

5 DIGITIZATION OF THE PROCESS OF TRAINING PUBLIC SERVANTS FOR E-GOVERNMENT IN UKRAINE

Ukraine's commitment for a higher level of e-government development opens up far-reaching opportunities not only for improving institutional processes and the efficiency of public services, but also for training civil servants. Training of highly professional heads of public institutions and competent civil servants is one of the prerequisites for creating an effective system of public administration. Since 2016, the specialty "Public Administration" has been introduced in Ukraine. More than 140 higher education institutions (HEIs) in Ukraine have a license for educational activities in this specialty.

The standard of higher education in Ukraine of the second (master's) level of higher education in the specialty 281 Public management and administration determines the formation of special competence "Ability to organize information and analytical support of management processes using modern information resources and technologies, in particular to develop measures for the implementation of e-government in various areas of public management and administration", as well as the learning outcome: "to identify priority areas for e-government and e-democracy" (MON, 2020).

Educational trends of recent years, modern learning conditions during the pandemic require introducing e-learning in the practice of civil servants' training from the leaders of these educational institutions, the requirement of time is the correction of the content and forms of education and the use of IT in research and teaching. Our analysis of the content of more than 50 educational programs, which provide training for civil servants in higher educational institutions of Ukraine, showed that most educational programs have mandatory disciplines that provide training for civil servants in e-government. These disciplines have different names, namely: "Digital and e-Government and ICT", "E-Government", "Information Policy and Digital Technologies", "Information Technologies, e-Government and E-Democracy", "E-Government, resources and services in the civil service", "Information and analytical activities in public administration","Informatics and computer technology","Information technology in public administration","E-government, information technology, resources and services on civil service", etc. In some master's degrees such disciplines are elective, their mastery depends on the choice of students.

Some higher educational institutions offer educational programs that are entirely dedicated to preparing for e-government. Thus, one of the leading universities of Ukraine "Kyiv Polytechnic University" offers an educational program "E-Government", which contains numerous disciplines related to the preparation for e-government, including "Information Security and Risk Management", "Information systems and Internet technologies in public administration","International and national professional standards in the field of e-government","E-government and e-democracy","Tools of e-government and e-democracy in preventing corruption", "Implementation of e-government", "Public procurement and e-commerce" (pdp.nacs.gov.ua, 2019).

Uzhhorod National University also provides training in the e-government educational program. This educational program contains the following disciplines: "Communications in public administration", "Architecture and information technology infrastructure of e-government", "Electronic document management and information security", "Foreign experience in e-democracy", "Information security in e-government", "E-democracy", "Benchmarking of e-government at the local level", "Theoretical and methodological, organizational and institutional basis of e-government", "Public administration in the development of the informatiion society", "Electronic services", "Information technology in the electoral process", "Marketing and management of e-government" (www.uzhnu.edu.ua, 2021).

The analysis of the content of education in Ukrainian master's programs testifies to the compliance of the content of civil servants' training with global trends in preparation for e-government. Analysis of the forms of the educational process organization shows that almost all master's programs offer full-time, part-time and distance learning, which corresponds to general trends and features of education during the pandemic.

On the basis of the Educational and Scientific Institute of Public Administration, Management and Postgraduate Education of the State Institution "Luhansk Taras Shevchenko National University" and Institute of Humanities and Public Administration of Ivano-Frankivsk National Technical University of Oil and Gas, which carry out educational activities for the preparation of masters in "Public Administration", a survey of civil servants on digitalization processes was conducted. The study surveyed 285 respondents who studied by correspondence over the past 3 years. The research group included civil servants of "C" and "B" categories from the regional administrations, district state administrations, as well as officials from city and village councils of Luhansk and Ivano-Frankivsk regions. Only 6% of respondents do not work in the civil service and local government and study on a contract basis. Figures 1 and 2 shows the characteristics of the group of respondents by age and length of service in public administration.

The characteristic of the respondents' group by age shows that the survey was conducted by people aged 21 to 60, among them the predominant age group is from 31 to 40 years (54%), people who usually have skills in the use of ICT technologies and are able to master new technologies in e-learning. The characteristic of the group of respondents by length of public service shows that the survey was conducted by experienced civil servants and local government officials. 51% of respondents have more than 5 years of experience in the public service, which makes their opinions valuable as experts on the processes of digitalization of public administration.

Respondents were asked to rate the level of manifestation of a phenomenon of digitalization on a 10-point scale (10 – maximum level, 1 – minimum level). According to the survey, 68.2% of respondents rated the impact of information technology (IT) on the effectiveness of public administration with the highest number of points (from 8 to 10), the lowest level of assessment – 5 points. The level of assessment of digitalization of public administration in Ukraine is estimated at a minimum of 2 points and a maximum of 10 points, the majority of respondents (81.4%) within 5 – 8 points. The level of digitalization of work processes in the organization at the place of work is estimated by the majority of civil servants (56.4%) within 5 – 6 points. Only 17.2% of respondents gave high marks (8–9 points). The minimum score on this issue within 2 – 3 points was given to 12.1% of respondents. The obtained data are indeed a subjective assessment of the respondents, but they indicate problems in the practice of e-government implementing. With this assessment, civil servants demonstrate their opinion that ICT technologies are used in half in terms of the possibilities of their use in work, the digitalization of public administration is under development.

The results of the assessment of respondents' own readiness for the use of ICT in public administration are shown in the diagram (figure 3).

Thus, most respondents acknowledge their willingness to use ICT technologies, which is a favorable factor for the digitalization of the public service and the introduction of e-learning for civil servants. The study also examined the impact of information technology on the learning process. Respondents' assessment of their own readiness to use ICT in the learning process and their self-development (figure 4) showed their confidence in their readiness for e-learning.

Also, the majority of respondents (62.6%) rated the increase in their level of ICT competence during master's studies in the range from 7 to 10 points. However, this issue was rated at 2 – 3 points in 13% of respondents, which may indicate insufficient use of ICT in the educational process.

To identify the trends in the development of e-learning for public servants, it was important to provide information on the results of the Delphi study of the ICT technologies impact on the educational process, identify the benefits and threats of the use of IT. This study was carried out in two stages. At the first stage the opinion of 285 undergraduates from the group of respondents on the benefits and threats of the use of ICT in the educational process was clarified as the result of the survey. Analysis and systematization of the obtained data, study of the scientific literature on this issue, our own research allowed us to form the lists of benefits and threats of e-learning and identify 11 benefits and 7 threats.

At the second stage, a group of undergraduates of the 1–2 years of study (48 people) acted as an expert group which corresponds the group of 285 re-

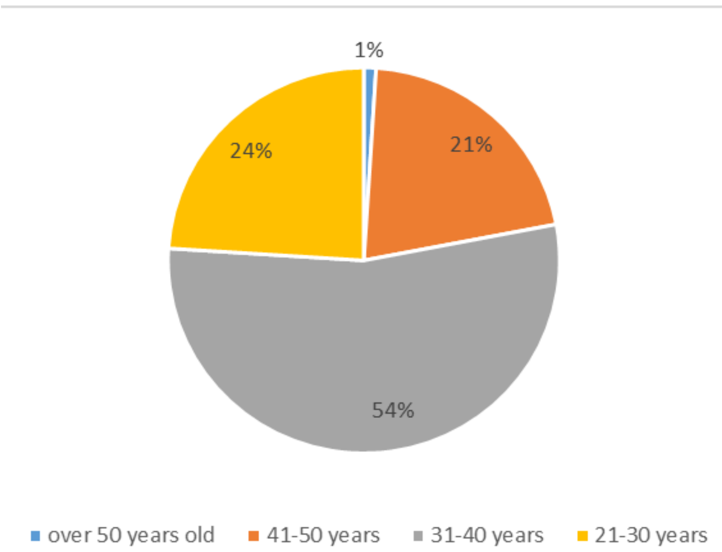

Figure 1: Characteristic of the respondents' group by age.

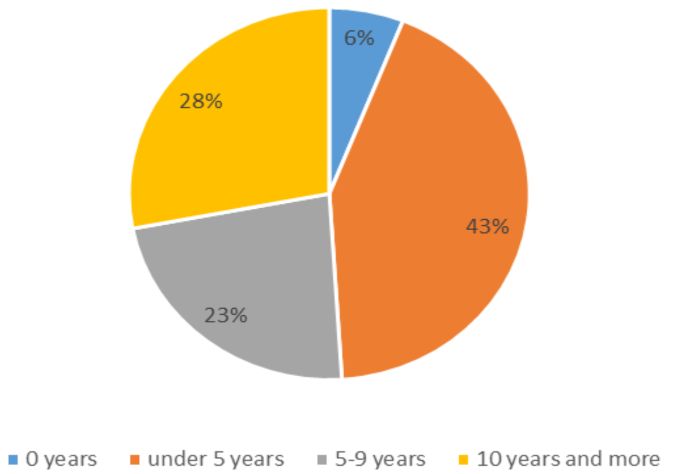

Figure 2: Characteristic of the respondents' group by length of work in public service.

spondents of specialty "Public management and administration" (on their age, qualification, work experience). The experts were tasked with assessing the significance of the proposed benefits and threats on a 10-point scale. Assessment was carried out on a 10-point scale, where 10 points of assessment correspond to the maximum level of benefits or threats of the use of ICT in the educational process.

The results of the expert group's assessment of the benefits of ICT for the learning process are shown in figure 5. These data are the average assessment of experts on the significant benefits of e-learning (Y axis). The numbers on the X-axis correspond to the advantages of using ICT in the educational process, where 1 – allow to increase the amount of educational information, 2 – increase the availability of information, 3 – facilitate communication with teachers, 4 – allow to solve organizational problems of the educational process, 5 – facilitate research, 6 – facilitate contacts with public officials of Ukraine and other countries.

The results of experimental work are confirmed by statistical analysis. For the main 6 indicators we obtained the coefficient of variation that does not exceed 0.28, and for insignificant 5 – from 0.39 to 0.62. This indicates a good relative consistency of experts' opinions on significant opportunities and satisfactory on insignificant ones. The concordance coefficient, which determines the consistency of the experts' opinions as a whole on the experiment, is equal to 0.66. This indicates a good degree of consensus

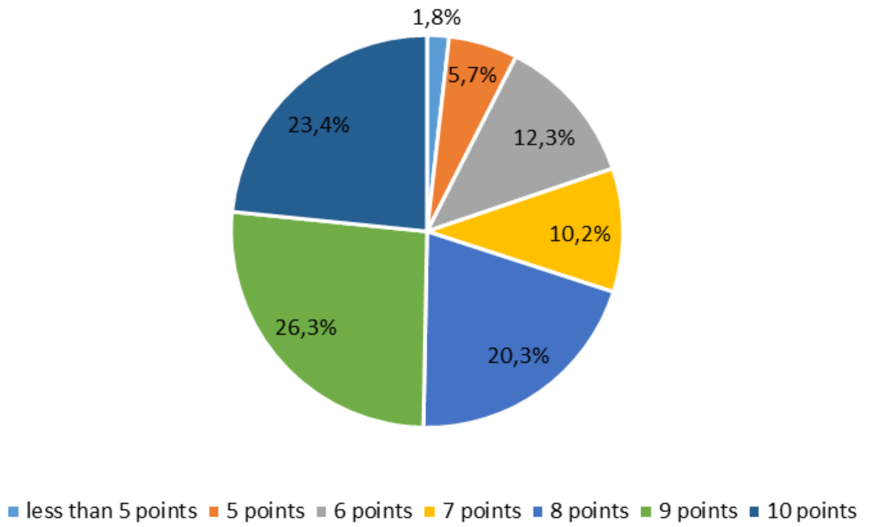

Figure 3: Results of civil servants' self-assessment of readiness to use ICT in public administration.

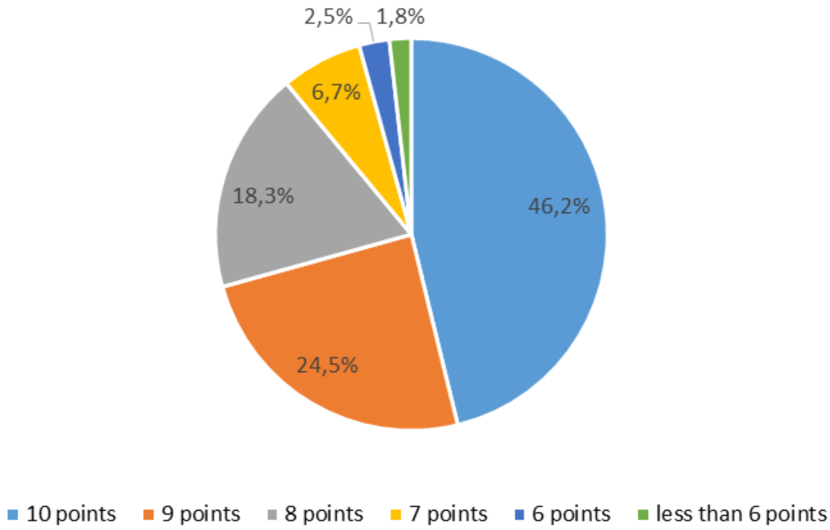

Figure 4: Results of civil servants' self-assessment of readiness to use ICT in the educational process and their self-development.

among experts.

Thus, the respondents rated the possibility of working with information the most (advantages 1, 2). However, such a result may indicate a lack of implementation other advantages provided by the use of ICT technologies in the educational process in domestic higher educational institutions.

The results of the expert assessment of the threats to the learning process that may be caused by the use of IT are shown in figure 6. The average score of experts (Y axis) is given in accordance with the identified threats, which are assigned numbers (X axis), where 1 – causes oversaturation of students with information, 2 – formalizes the learning process, 3 – promotes plagiarism, 4 – IT capabilities that used in the educational process, constantly lagging behind their world level.

Statistical analysis confirmed the reliability of the results of experimental work. The coefficient of variation for significant 4 indicator does not exceed 0.26, and for insignificant 3 – from 0.41 to 0.47, which indicates a good relative consistency of experts' opinions. The concordance coefficient (0.74) indicates a good degree of agreement between the experts' opinions of the whole experiment.

As can be seen from the above data, respondents

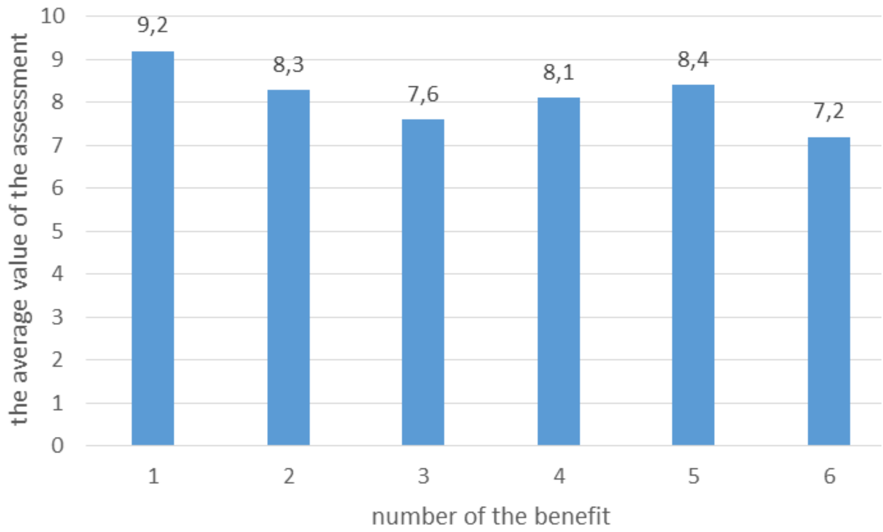

Figure 5: The results of the assessment of the benefits of the use of ICT in the educational process.

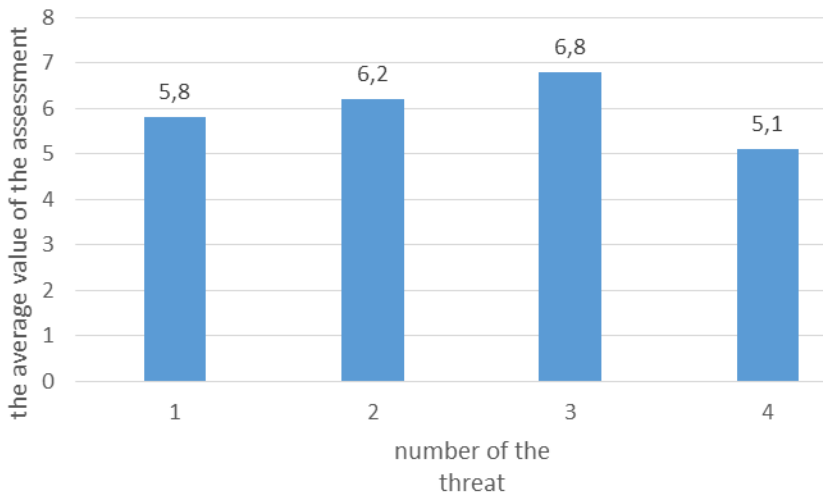

Figure 6: The results of the assessment of threats to the learning process that may be caused by the use of IT.

see a greater threat to the consequences of the introduction of ICT technologies in education in the formalization of educational process and the creation of favorable conditions for the spread of plagiarism. Thus, actions to prevent these threats are the use of innovative interactive methods of teaching and conducting a policy of academic charity in domestic higher educational institutions. The solution of this problem will be facilitated by the use of modern information technologies and the direction of funds for the provision of educational process with modern technical equipment and software.

Therefore, according to the results of the analysis it is established that:

- e-learning is an important means of preparing public servants for e-government, which allows them to respond to new challenges of today and implement training in modern conditions;
- e-learning allows civil servants to combine work and study;
- e-learning corresponds to the age characteristics of the majority of public servants who study in the master's programs of higher educational institutions;
- awareness of the benefits and threats of the use of ICT in the training of civil servants, taking them into account in the management of civil servants' e-learning will improve the quality of the educational process;

- In general, the content of education in master's programs of Ukrainian higher educational institutions, which train civil servants, is aimed at the formation of professional competencies necessary for e-government, and corresponds to global trends in training of civil servants.The obtained data are taken into account when determining trends in the development of e-learning for civil servants.

6 THE RESULTS OF THE RESEARCH

According to the results of the study, the following trends in the development of e-learning for civil servants are identified:

1. *Transformation of e-learning into one of the main factors in the development of public servants in the world.* Its volumes are constantly increasing, its technical and software base is being updated, and its level of availability is increasing. E-learning is implemented in the form of distance education, blended learning and a component of the traditional classroom organization of the educational process. The main feature of e-learning is its focus on the learner. It allows you to implement the individual characteristics and needs of students better, and this is the key to higher efficiency of this level of training of public servants. E-learning allows to save financial, material resources, time resources and social work due to its flexibility, logistics, organizational forms. Therefore, we can predict the development of the global trend to increase the volume of e-learning for public servants.

For a long time training has been a means of transmitting the accumulated knowledge to the new generation. But now the situation is beginning to change. There are several factors involved in the training of public servants: rapid changes in the social situation, the emergence of problems that do not have ready-made solutions. High level of education of public servants, who, as a rule, have higher education and are more focused on active work than on passive perception of ready knowledge, this statement is confirmed by the data obtained by us during the survey.

Our analysis of the training experience of civil servants showed that institutions training civil servants can be divided into two groups: the larger group focuses on the translation of best practices of public administration, and the second focuses not only on learning effective public administration experience, but also on developing its models appropriate to rapid changes in social processes. . The approach of the first group of institutions is focused on yesterday and today's public administration and is doomed to constantly lag behind the existing problems. The second approach is focused on today and tomorrow of public administration, so it determines the competitive advantages of educational institutions implementing this approach. The first approach is more common in postgraduate institutions that provide certificates after graduation. The second approach is common in leading universities, which have significant potential of scientists, teachers who specialize in public administration.

Information technologies create fundamentally new opportunities for the development of civil servants. This effect is achieved through the ability to choose courses to study according to their needs, learn at a comfortable pace, combine theoretical training with the practice of civil servants, communicate with teachers, other students from different countries, receive text, video and audio information, use different learning devices. It allows turning the usual traditional learning process into a collective research and project activity of international groups of civil servants, who will study certain problems of public administration and experience of different countries in solving them and develop innovative models of their solution and implementation with the help of network technologies.

2. *Orientation of the e-learning system to increase the level of subjectivity of civil servants.* E-learning has more opportunities to make decisions about this process. In this situation, the effect of resistance to learning disappears. This effect is characteristic for adults in the system of traditional learning, when they don't neet to solve problems themselves. Thus, e-learning is more in line with the features of the modern Internet generation of public servants, more prone to activity, flexible response to events, information challenges, to interactive teaching methods.

Civil servants of the Internet generation, provided a high level of motivation, can learn using e-learning technologies. Readiness for such training was confirmed by the results of the civil servants' survey in our study. In this process, there is no need for a personal teacher who controls and dictates the rules of educational activities that are characteristic of formalized education. E-learning is the most effective way to implement the idea of lifelong learning.

3. *Diversification of content, goals, subjects and approaches to the organization of e-learning.* Analyzing the system of teaching e-government in terms of content, we can distinguish several groups of courses:

- Project management of e-government development (Innovations in digital self-government and services, E-government assessment, Augmented reality, blockchain, Context services, e-government strategy, government 3.0, government 4.0, Game-based modeling; Policy modeling paradigms, gender and ICT , intellectual management);

- Management of information systems and databases (Smart Government, Software Development, Information Society Principles and Public Administration Information Systems, Geo Information Systems, Government Social Media, Big Data, Cloud Computing, Smart City and Open Data, Cloud Services Integration, Information Management and Digital archiving, use of virtual environments, database management systems);
- Informatization of public services (Technologies and e-government services, personalized public services, proactive services, Contextual services, Blockchain public services,)
- Fundamentals of cybersecurity (e-Identity / e-Signature, Digital certification, Security and authentication in public administration, Impact of social bots, transparency and trust in decision-making, open data, e-participation systems).

The purpose of training civil servants is to ensure the mastery of ICT technology in public administration for marketing, monitoring, service delivery, communication technology, research, exchange of experience, obtaining information, storing information, information processing.

E-learning allows to solve many tasks: to solve problems of public administration at current levels and to break the circle of erroneous situation when management becomes a prisoner of accepted procedures of public administration, to form global values of public administration, to establish informal connections of people from different countries and intercultural dialogue, to use the potential of national diversity to solve state problems, to form a number of important competencies of employees, to give public administration a research character, to update the teachers' traditional functions.

Nowadays, curricula are offered by different types of institutions: universities, colleges, state administrative institutes, government agencies, banks, public organizations, associations, networks.

The analysis allows us to identify several approaches to building e-learning – focus on the best practices of e-government, focus on highlighting the theoretical foundations of public administration, focus on the implementation of e-government, focus on development, research of e-government, which provides advanced nature of training, focus on the needs of students, focus on the formation of certain competencies of each group and individual employees. Typically, some of these learning logics may be leading and others complementing them, or these logics may be compiled or used systematically. The condition for improving the effectiveness of e-learning is the conscious construction of a holistic logic of the educational process.

4. *Multifunctionality of the use of information technology in the training system of civil servants.* Information technology has several functions: the object to be studied; tools for solving marketing problems; technologies for solving educational tasks - organization of educational tasks, communication with teachers, colleagues; exchange and receipt of information, control of knowledge and evaluation of learning effectiveness, accounting for learning outcomes; organization of scientific research; information storage; establishing relations with graduates, institutions where students work; means of preparation for standardized and specialized information tasks; means of the development of public administration.

There are standardized and specialized information tasks in civil servants' activity which are based on the use of specialized software. The training system for civil servants, focused on obtaining certificates, usually prepares for the solution of standardized information tasks, and the system of master's training provides preparation for more specialized information tasks.

The training of civil servants for the use of information technology in public administration can be effective only against the background of a holistic consideration of the problems of public administration, which is a system-forming factor for ICT. Problems of e-government can be considered at the side of public administration or ICT. The first position is more reasonable because ICT is a component of public administration, and not vice versa. ICT is a tool, although the main one, for solving the problems of public administration. But we should take into account that ICT can change not only the content of management, but also its tasks.

5. *E-learning of civil servants creates conditions for cross-cultural interaction.* E-learning allows to organize research, project activities, communicate with teachers, students, representatives of different countries, quickly receive and transmit information. These benefits of e-learning were highly rated by respondents in our survey. It changes the essence of learning, which loses its traditional meaning and turns into a new kind of collective social activity of transforming the surrounding reality. E-learning creates conditions for exchanging teachers from different coun-

tries, internationalization of the content of education, the formation of an international theory of public administration.

This trend is most actively beginning to manifest itself in the system of master's training of public servants and e-learning plays a leading role in this process. But the further spread of e-learning can facilitate formalization the learning process and create favorable conditions for the spread of plagiarism. Such threats were identified during the study, that is why it should require the formation of e-learning culture and the implementation of academic integrity. The further spread of e-learning will inevitably lead to its transformation into a new activity in which knowledge will be only one of its conditions, and competencies will be a concomitant result of certain changes in public life. In this situation, e-learning will be a part of the public servants' work, which will not require special educational institutions for its organization.

The relevant problem for further research is the problem of studying the impact of the training system of public servants on achieving high level of e-government in the world's leading countries on this indicator.

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Perception and Interpretation of Emoji in the Pedagogical Process: Aposterior Features of Artificial Digital Language

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Keywords: Emoji, Artificial Languages, Digital Communication, Perception, Interpretation, Mental Frame, P-Semantics, Sign.

Abstract: This study is experimental. The investigation is based on data collected from an experiment that was conducted involving participants in the educational process. The essence of the experiment is to test the artificial digital language of emoji in the learning process from the standpoint of both teachers and students in the field of education. But the experiment was augmented by representatives of other professions (programmers, economists, artists, writers), which helped to expand the object of the study, extrapolating the findings of the experiment on different areas of activity surveyed. The results were obtained for the following categories of respondents: age, profession, knowledge of foreign languages. Experimental data helped revealed the following issues: 1) artificial emoji language reproduces polylaterality in structure (elements of sign generation) and semantics (multi-vector perception and interpretation of the sign). This explains the scale of differentiation of emoji characters; 2) the polylateral perception and interpretation of emoji depends on the speaker, which in study was classified according to the above categories. It was concluded that the perception and interpretation of the emoji sign depends on all the highlighted categories with an advantage to the professional activity of the speaker and their experience in a particular profession. The concept of a priori and a posteriori of artificial languages was also revealed for the purpose of the research. Language of emoji we categorize as an apriori-posteriori since by form and meaning digital emoji signs display features of both types: the shape of the components of the emoji sign refer to other semiotic systems (such as cuneiform or Morse code); in terms of content, the emoji sign in digital communication can be interpreted depending on individual verbal skills, which, in turn, was considered through the prism of frame semantics (P-semantics) of Charles Fillmore. The experiment results demarcated perceptual characteristics and interpretation of digital emoji signs by respondents depending on the nature of their professional activity. Thus, it was concluded that representatives of the humanities and social sciences (both in service teachers and applicants for the pedagogical profession) and representatives of sciences (economists, programmers) have antithetical properties of perception and interpretation of emoji in digital communication. This coincides with the concept of mental frames embedded in the thinking structure of each individual. The prospects of this research consist of bringing other educational professionals into the experiment, as well as non-teaching professionals to determine the deductive hypothesis of the role, function and influence of digital language of emoji on teachers and non-teachers. The latter will make it possible to identify the advantages and disadvantages of digitalization of society both in the educational process and outside its framework.

1 INTRODUCTION

Modern specialists in the field of computational linguistics (Anber and Jameel, 2020; Annamalai and Abdul Salam, 2017; Brody and Caldwell, 2019; Chichón and Jiménez, 2020; Schmidt et al., 2021),

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test the idea that emoji is now a promising means of pedagogical communication. Evans (Evans, 2015) emphasizes that emoji have enormous potential in transferring meaning of the phrase and its shades of emotions (Piperski, 2020). In the conditions of modern globalization and digitization, which the philological sciences have not escaped, the use of visual elements in messages has become the norm. The approach has changed to interpret many of the problems of text linguistics. Recently, researchers have begun to actively study ways of transmitting and perceiving information using semiotically complex or creolized text. By *semiotically complicated text* we mean a non-linear (palindrome in form and perception) text, the content of which can be transmitted by one or more optical signs. This creation of the text refers us to pictographic and hieroglyphic writing, which is characterized by an emphasis on visual reading of the content.

However, it should be noted that the digitalization of the traditional text with the help of ICT reveals a new communicative barrier – the problem of sign interpretation. In our article (Makhachashvili et al., 2020) the technology of visualization of the text of fiction (poetry) with the help of emoji symbols on the Emoji-Maker platform was presented. During the research we came to the conclusion that such an emoji ICT experiment activates students' thinking, develops creative attention, gives an opportunity to concisely reproduce the meanings of poetry (Makhachashvili et al., 2020). However, at the same time, the above-mentioned problem of sign interpretation was revealed, since the mental frames of a person, which depend directly on the genetic structure of thinking, take part in the generation of an optical sign. This, in turn, leads to the fact that not only the perception of the sign will have differences, but also the basis of its generation (geometric shape, color, emotion, association). Makhachashvili and Bakhtina (Makhachashvili and Bakhtina, 2019) consider this problem through the prism of L. Wittgenstein's hypothesis about individual language ("Sprachspiel"): "Note that the human brain copies the structure of only one language (genetic), despite the possession of two or more people. foreign languages. Therefore, if the dialogue takes place between people in one language, it does not mean that they reflect the structure of the symbolic system of dialogue. Genetically (mentally – in L. Wittgenstein) they structure and, accordingly, perceive and interpret the text differently. And this distinction occurs due to the neural network formed in the structure of genetic language in the human brain" (Makhachashvili and Bakhtina, 2019).

Since this digital technology is of great interest in the field of philological communication today, we believe that the further development of text visualization technology will contribute to the effective study of fiction by students of philology. However, in our opinion, it is worth paying more attention to the problem of interpretation of the sign, because in the global sense, the level of understanding between humanity depends on it. Therefore, appealing in the article (Makhachashvili et al., 2020) to the experiment with students generating optical text on the material of fiction (Fane, 2017), the team conducted another experiment. Its purpose is identifying features of posteriori construction of an artificial sign in digital communication, dependent on perception of both students and teachers.

The objective of the paper. Systematic analysis of the empirical method in the study of interpretation of the optical emoji sign during its generation and perception, which will trace the semiotic transformation in the analysis of transgression of signs from natural languages into digital artificial (a posteriori) ones, in particular emoji. Determining the pedagogical perception of the optical sign is made possible by the fact that the experiment involved not only teachers and students of philology, but also representatives of various fields: historians, economists, programmers, mathematicians and others, which allows to compare perceptions and interpretations of artificial emoji.

First of all, let us define what is meant by the aposteriori nature of artificial languages. We use this definition through the work "Construction of languages: from Esperanto to Dothraki" (Piperski, 2020), in which the author explains the difference between a priori and a posteriori artificial languages: "Most early artificial languages were created by philosophers and had an a priori nature; this means that they were not based on existing languages, but were created on arbitrary principles… Beginning in the XIX century, artificial languages were usually a posteriori, i.e. to some extent created in existing languages…" (Piperski, 2020). However, note that we refer the emoji language to some extent to apriori-posteriori type because that language is originated in the computer being (hereinafter – CB) – a complex, multidimensional field of synthesis of reality of human experience and activity mediated by digital and information technologies; technogenic reality, a component of the technosphere of existence (Makhachashvili, 2013). Thus, like a priori languages, emoji is classified as a logical language (loglang) – a programming language. This dual nature is prompted by the fact that emoji was first created by a Japanese designer Shigetaka Kurita (Negishi, 2014), who became the first 176 characters for Japanese users of the i-mode mobile platform. The pictures he created (12x12 pixels) correlated with the lives of the inhabitants of the city of the founder (Gifu Prefecture, Japan), reproducing the most common discourses of real communication. Therefore, taking as a basis the idea of manga – one of the forms of Japanese art, Kurita reproduced pictographically elements of Japanese culture, and the phonetic coincidence of the word emoji is accidental. Already in Unicode Consortsium emoji received the meaning of emotional characteristics.

In our study (Makhachashvili et al., 2020) the role of the reader-interpreter is emphasized, which allowed us to conclude the following: recipient (reader-interpreter), using specific technological tools, a visual iconic sign (smile) reproduces the polylateral metalinguistic functionality of the meaning of the sign on the basis of the artistic word (Makhachashvili et al., 2020). The results, on the one hand, complicating the structure of semiotic field of artificial sign, on the other hand – expanding mental frames of human thought, explicates the emoji sign as universal rather than local or mental (the latter, in turn, is confirmed that, once adopted by the Unicode Consortsium, emoji transgressed into the international language of characters, the creation of which has become purely digital). Versatility and digital conditionality of emoji provides multi-vector semantic load of the sign. Addressing this issue, Makhachashvili and Bakhtina (Makhachashvili and Bakhtina, 2019) introduced the linguistic concept of "polylateralism" – (from the ancient Greek πολύ – many; from the Latin latus – side) – a category that reflects in the digital emoji sign versatile, multi-vector reproduction of emotions through logical-structural, lexical-grammatical, morphological, etc. means (Makhachashvili and Bakhtina, 2019).

So, appealing to the logic (a priori) and a posteriori of the artificial digital emoji language, and based on research on this topic, we propose the rundown of the pedagogical experiment. We aim to trace how emoji is used in the learning process through digital communication, what criteria are used by educators and learners when constructing an artificial sign, which plays a special role in the interpretation of a particular emoji.

2 RESEARCH METHODOLOGY

To solve the delineated tasks, the following methods were used: analytical review – for the study and analysis of scientific and methodological literature, curricula, generalization of information to determine the theoretical and methodological foundations of the study; pedagogical modeling – for the study of pedagogical objects through the modeling of procedural, structural and substantive and conceptual characteristics and individual "aspects" of the educational process. Empirical method – in order to study the phenomenon through experiment and rational processing of the obtained data. Structural method – in order to identify and analyze structural elements, individual components, categories, etc., which form the emoji-sign. The method of component analysis – in order to identify the minimum semantic (semantic) elements that form the semantic component of the sign. Semiotic method – in order to study the sign from the standpoint of its organization, the properties of its elements and categories. Descriptive method – in order to describe in detail, the language units in the inventory and systematization. Dialectical method as a way to find a theoretical construction of the linguistic picture of the world, the study of the true criteria for the coexistence of language and the world, language and man, language and machine. Logical-analytical methods, namely the method of induction and deduction, which allows to consider the content of the object, specifying and generalizing its concept; the method of formalization as the study of an object by reflecting their structure in symbolic form.

3 RESEARCH RESULTS

In order to identify differentiation in the interpretation of emoji, we conducted an experiment involving 110 respondents aged 10 to 70 years (figure 1). Such a large-scale coverage of the age category allowed to fundamentally reflect the picture of the world and digital literacy of mentally different representatives, and also allowed to distinguish groups of people whose linguistic pattern differs significantly from respondents of other age categories. All this is directly reproduced in the interpretation of the optical digital sign. Thus, the results of the experiment show that emoji is used more by respondents whose age range is from 10 to 20 years, and to a lesser extent – from 40 years (figure 2). Accordingly, such results explain the verbal skills of the recipients, depending on the professional and mental qualities, which will be discussed later.

Since the experiment was conducted in order to identify functioning of digital emoji language in the pedagogical process, divided into various narrow fields, the part was taken by representatives of the following professions: philology (educators (lecturers, teachers) and students). However, the validity of the experimental field increases due to the participation

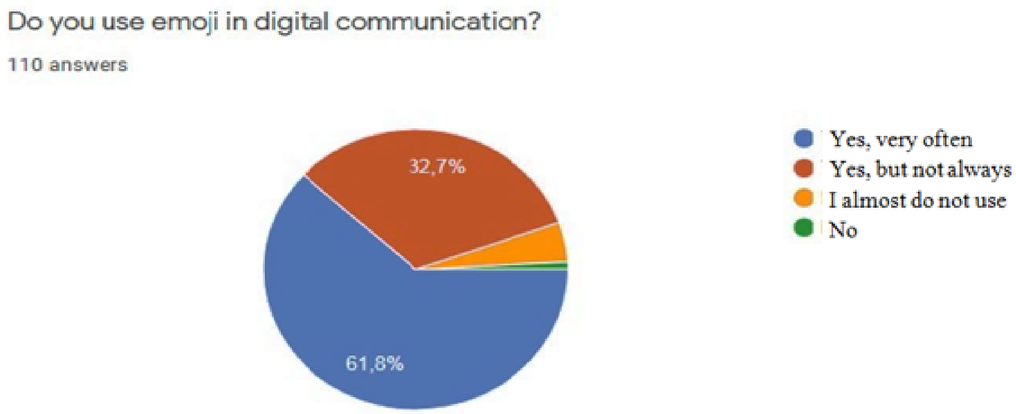

Figure 1: Frequency of emoji usage in digital communication.

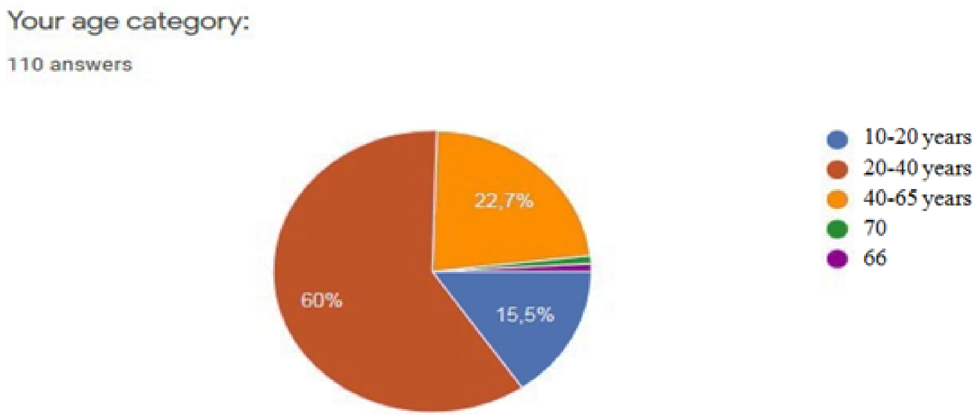

Figure 2: Age brackets for emoji users in digital communication.

in the experiment of representatives of the following fields: history, IT, mathematical modeling, publishing, choreography, psychology, economics, diplomacy, archeology, IT, fine arts. The status of the respondent varies from student to habilitated doctor. The wide scale of profile differentiation fractalizes semantic shifts in the interpretation of a sign in more detail. This is characterized, in addition, by the choice of social network, where the respondent uses emoji (figure 3). We can see that most age groups of recipients use Facebook, Instagram, Twitter. However, the age group of up to 20 years tests artificial languages on other platforms (Tik-Tok, Discord, Tumblr), which is also reflected in the verbal skills of the recipients. In terms of professional affiliation, Facebook is more used by the teaching staff of various universities (59.1% of respondents); Instagram – by students of different universities – 67.3%, other social networks – by the lowest percentage of respondents, which is fractalized to all categories of respondents.

Another important characteristic of differentiation and fractalization of answers is mastery of foreign languages. Among the respondents were experts in the following languages: Russian (99%), English (98%), Spanish (74%), Italian (49%), French (49%), German (23%), Chinese (4%), Japanese (2%), Korean (1%), Czech (1%), Polish (1%), Georgian (1%), Armenian (1%), Hebrew (1%), Turkish (1%). Therefore, the results concluded that the use of emoji in digital communication (both in everyday life and in the professional sphere) is more pertinent to recipients with knowledge of two or more foreign languages (table 1). However, the interpretation of a particular sign varies and depends on a particular foreign language (and / or on professional skills). Emoji is a typical visual complement to the content of text / speech in digital communication for experts in Oriental languages, including Mandarin Chinese, Japanese and Korean, which, in turn, refers us to the mental frames of Oriental language structures. Fillmore (Fillmore, 1985) classifies frames as P-semantics, which operates with the concept of interpretive description of the semantics of tokens, grammatical categories and text. Such semantics includes three components: compositional semantics (frame structure of the text), practical reasoning based on the use of frame knowl-

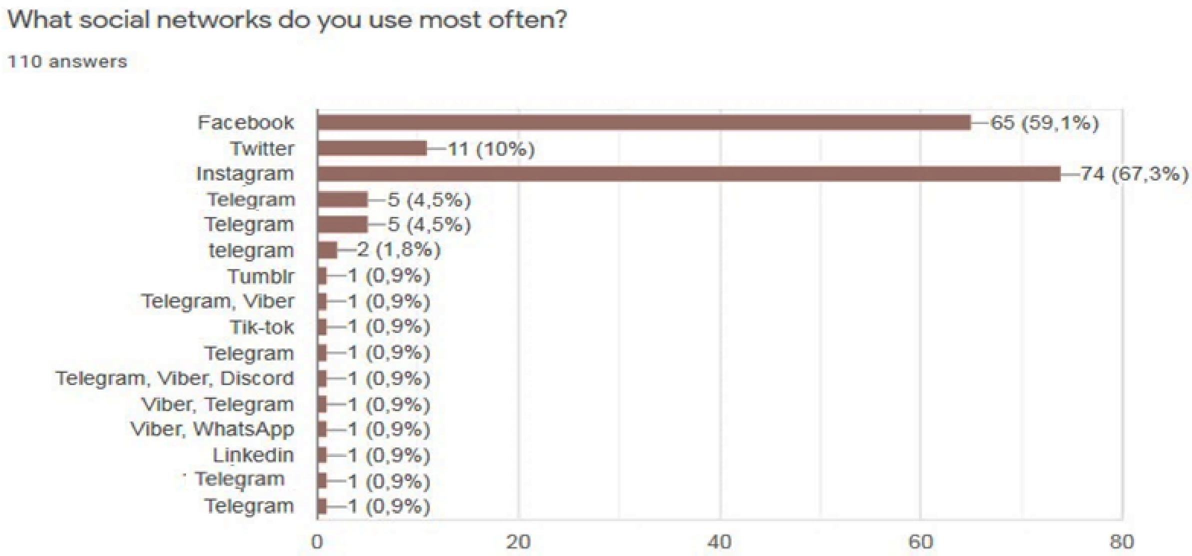

Figure 3: Choice of social network, where the respondent uses emoji.

edge (knowledge of reality) and provides identification of implicit semantic connections between utterances in the text; reasoning based on knowledge of communicative intentions represented in frame form. In the situation of reasoning, natural-linguistic inference is considered as a set of operations on the elements of frames (Fillmore, 1985). Reliance on the frame structure also applies to experts in the Spanish language (74%). However, it's worth noting that in Hispanic communication emoji has emotional presupposition: Spanish language professionals a priori interpreted emoji of a psycho-emotional meaning, mostly adiaphorizing rational structure components of the sign. The positive attitude and use of emoji is also observed in the professional specifics, in particular, artists who, unlike experts in Romance languages, appeal to real causal (implicit and semantic) connections both between utterances in digital communication (emoji) and between components of one sign.

The most unexpected among the results of the survey were the responses of computer science specialists, whose attitude to emoji was twofold. However, we can assume that experts in the field of IT completely include emoji in the loglan, which apriori cannot have an emotional substrate. Computer science specialists, in turn, perceive not so much a language as its matrix. Under such conditions, the logical indicator is that the most extensive use of emoji is in the humanities (philologists, historians, philosophers), the specifics of whose profession refers to information as a tool of influence, which is directly inferred from the emotional substrate. To a lesser extent, emoji is used by the exact sciences specialists,

Table 1: Distribution of native languages spoken by emoji users.

What languages do you speak?	% of respondents
Ukrainian	100%
Russian	99%
English	98%
Spanish	74%
Italian	49%
French	49%
German	23%
Chinese	4%
Japanese	2%
Korean	1%
Czech	1%
Polish	1%
Georgian	1%
Armenian	1%
Hebrew	1%
Turkish	1%

the results of whose activity are represented by numerical data. The smallest percentage – computer science specialists, where the result is a matrix. The same effectiveness, as in the above case, applied to the interpretation of the concept of emoji (table 2). Artists and / or Oriental and Romance languages professionals emphasized the iconicity / ideography of the sign in digital communication, the graphic visualization of which is independent of the narrative form, but performs the contractual function of an auxiliary non-verbal explicant. Specialists in the humanities focused on the emotional characteristics of the sign, which is designed to enhance the effect of the communicative act in digital medium.

We mentioned above the verbal skills of the recipients, which, like the previous features, depend on age, professional activity and knowledge of foreign languages. In order to trace the differentiation of the perception and interpretation of the emoji sign, 10 most used emoji in different operation systems and digital platforms were added to the survey in order to trace how the respondent understood each sign. In addition to the characteristic of popularity, the dual or polylateral nature of the sign was an important factor in choosing emoji for the experiment, which hypothetically refers to the conclusion about the differentiation of the perception of signs by each recipient. Thus, the sign #1 (figure 4) for 99% of respondents is interpreted unambiguously, with deviations of the semantic load in 1%: ok, good, cool, great, well done, good job, very good, super, perfectly etc. However, from recipients aged 10 to 20 we have answers that reflect age-related deviations in perception, for example, “I like it (smiley is not very much, my grandmother throws me and teenagers use for this ☺)”

Figure 4: Emoji sign #1.

A similar perception applies to the sign #2 (figure 5), the interpretation of which is 100% synthesized with a negative connotation and explicated within one semantic field. However, given the scale to differentiate the characteristics of respondents, the verbal definitions of the sign can be traced to the structure of the linguistic ousia of answers, hypothetically deducing the nature of the category / profession / status / experience of a particular answer (table 3).

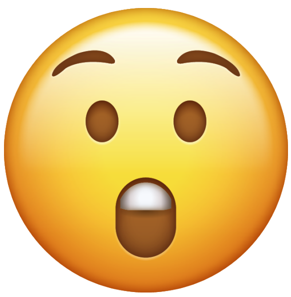

Figure 5: Emoji sign #2.

The sign #3 (figure 6) in digital communication embodies the polylateral structure of perception and interpretation. The answers to this sign are radically different (table 4).

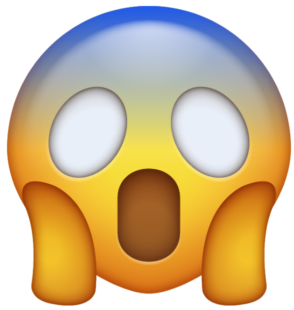

Figure 6: Emoji sign #3.

Perception and interpretation of the sign varies within the concepts of “horror”, “shock”, “fear”, “surprise”. Accordingly, it will be appropriate to emphasize the characteristics of the recipient to trace the frame structure of speech and verbal skills of respondents. Thus, the sign #3 is interpreted and perceived as horror in the category of 20 to 40 years (60%), shock – from 10 to 20 years (15.5%), fear – from 40 to 65 years (22.7%), as well as 66 years (1%) and 70 years (1%), surprise – from 40 to 65 years (22.7%). According to professional characteristics, the answers are fractalized into all categories evenly.

The situation with the sign #4 is more unambiguous (figure 7). However, it should be noted that the age categories 10 to 20 and 20 to 40 years in most cases interpreted the sign in terms of CB exclusively, emphasizing the digital continuum, in contrast to other categories that described the sign purely emotionally in the real ontological dimension (table 5).

Figure 7: Emoji sign #4.

The sign #5 (figure 8) expresses an error in interpretation and perception of 2%. Among the most typical – “sadness”, “tears”, “sadness”, “fiasco”, “pain”. The sarcastic connotation of the use of the sign in digital communication (age category from 40 to 65 in the humanities) (table 6) has to be emphasized, as well as despair, depression, fatigue (age category 10 to 20

Table 2: Interpretation of the concept of emoji by respondents.

How do you understand what emoji is?	
Emoticons	Facial expressions in social networks
Emoticons	A kind of graphic language
Emoticon	Mood display
Smileys	Face sticker to emphasize or express your emotions in the message
Expressing emotions with pictures	The language of various graphic signs
Small pictures used to indicate emotions	A picture that reproduces feelings, understandable to both the recipient and the author of the statement
Signs	A graphic sign, an illustration that conveys a certain concept, is used when communicating online
A symbol for conveying the emotional side of communication	Psychological state that reflects the instantaneous reaction to external factors
Graphic symbol for emotions and states	Coloring of the written text and accessible expression of emotions
A picture depicting a certain emotion	Emotions that help to convey more clearly our emotions, state, attitude to the situation, feelings, and sometimes due to emotions you cannot even write a text.
Emoticons designed to facilitate communication and convey different states / emotions	Mini drawings to indicate emotions, objects through which it is possible to convey information
Expression of emotions with the help of visual images	Use of digital symbols to demonstrate emotions, feelings, personal reaction to messages, photos in online communication
A picture that helps you show your own emotions in text messages	Auxiliary ideographic record

Table 3: Generalized definitions of Emoji sign #2.

What does the following emoji mean to you?	**In what context could you use it?**
Surprise	Means surprise, used as a reaction to a message, be it a photo, video or news
Shock	When I realized that 1 course had already ended
Oh really!	You can go crazy, but really
Wow	Surprise. Hidden irony (rare)
To indicate surprise / astonishment, but mostly with a positive connotation	Incredible!
Surprise, admiration	Surprise from the written (description of actions in the message)
Horror! Shock! What is happening!	Surprise from the situation or from the words spoken

Table 4: Generalized definitions of Emoji sign #3.

What does the following emoji mean to you?	**In what context could you use it?**
What a horror!	Omg! Strong surprise with hints of feelings for the interlocutor
Stupefaction	Horror; surprise in a negative context
Cannot be	Madre mia! in a bad way
"Horror" – wrote a work on one topic, and it was necessary on another))	Drip! It is too much! I'm shocked!
Horror! / Reaction to something very unpleasant	Oh my God!
To indicate surprise / shock, but not only with a positive connotation. Sometimes as a synonym for the expression "Oh, only!"	Reaction to unexpected news, surprise
Oh no! What?	Something fascinating
People are good, the house is white	Surprise. Negative or jokingly negative context.

Table 5: Generalized definitions of Emoji sign #4.

What does the following emoji mean to you?	In what context could you use it?
Love	I really like it, I support it very much, thank you very much
I like something	I like you
I love you!	Support, admiration
Wonderful	"Magical!" (positive warm attitude, especially to something sweet, sweet)
"With love" – especially a warm relationship, thank you	What I see is beautiful
Fascination with news / comments from a close person / child / friend	When I saw the puppy
See something cute, beautiful	Friendship compassion
Fascination with news / comments from a close person / child / friend	It has many meanings: it conveys pleasant amazement, joy, admiration for beauty, love

years – students) – with appropriate explanation by the recipients of their interpretation and perception: term finals at the university).

Figure 8: Emoji sign #5.

The sign #6 (figure 9) is identically interpreted and perceived by the respondents, but there is a differentiation in the verbal reproduction of the sign. Thus, respondents with an age category ranging from 10 to 20 years, as well as specialists in Germanic languages have the signification "*kiss*"; from 20 to 40 years (respondents of the humanities) – "*flirtation*", "*love*", and respondents of exact sciences – "*Air kiss*", "*I kiss and love*". "*You are very dear to me*". Respondents between the ages of 40 and 65 provide a more detailed lexical field, giving the signifier an explicit character: "*You are my good, thank you. A sign of support, gratitude, approval, support*". The results showed that such an explication would be more typical for teachers with sufficient experience in educational institutions, mainly in the humanities. It is noteworthy that IT professionals do not visually perceive the sign for two reasons: 1) this symbol can be used only with the close social circle; 2) visually do not like the symbol. This perception once again concludes the structure of thinking of specialists in the exact sciences, the result of which is a number / calculation / matrix.

An ambiguous picture is observed with the sign #7

Figure 9: Emoji sign #6.

in digital communication (figure 10), because according to previous experimental empirical data, it was stated that the sign has a latent negative connotation. In order to confirm or refute the station, the mentioned sign was placed in the questionnaire. The results showed a proportion of 60/40: 60% of respondents, whose age category is mainly from 20 to 40 (23%) and from 40 to 65 (37%), perceive and interpret the sign, emphasizing the neutral and / or positive connotation that explains approval of something ("okay", "good", "super", "yes" etc.). However, 40% of respondents (mostly humanities students – age group 10 to 20 years, as well as representatives of creative professions – artists, writers) see in the sign a negative connotation, which is characterized by several expressions: either sarcasm, or contempt for the interlocutor, or attempt to maintain one's opinion (table 7).

It was experimentally interesting for the authors of the study to trace the emotional characteristics of the sign #8 (figure 11).

Undoubtedly, the sign is an identifier of the global civilizational phenomenon of modernity, which led to the global pandemic – the coronavirus in COVID-19. Specified sign, in fact, with appeared in digital communication usage at the beginning of the quarantine, which covered virtually the whole world. However, computer being eliminates any locality, leaving in the

Table 6: Generalized definitions of Emoji sign #5.

What does the following emoji mean to you?	In what context could you use it?
I'm crying	When I want to emphasize my fatigue from something, irritation, helplessness
Very sad	Difficult situation
Sadness / crying	Sorry, pain, injustice
Tears, sadness, can be sarcastic	Notification of bad news, reaction to something sad
"Sorry" – disappointment, sadness	I forgot to attach the file to work
Disappointment when something failed, but this smiley still has a humorous connotation. In my opinion, it cannot be used as a reaction to the news related to the deterioration of human health, or, God forbid, death.	Something tragic
frustration in life	"but not what the stars are so united, I will not give up" + hyperbolization of real disappointment
frustration in life	When something is difficult / impossible to change, but I would like to.
sadness or tears with irony / sarcasm (any context)	Personal correspondence or friendly, reaction to the message

Table 7: Generalized definitions of Emoji sign #7.

What does the following emoji mean to you?	In what context could you use it?
Like	Keep it up, super
Super	Short answer to the sign of approval, support, acceptance of information
OK	Very good, or sarcastic
"good idea"	"approval" (neutral)
Well done! – approval	Means that the above seen cool (accompanied by other emojis can mean causticity, on the bag, generally expressing both good and evil)
Well done / class! / Great job! / OK	Approval of user message (actions described in message)
Class, great, thanks! All is well! Most likely, it is a response / reaction to someone's fulfilled request or reaction to the news and carries approval, or sometimes this smiley is a neutral response.	Again, it can mean either satisfaction and approval, or I use it in an ironic sense
postironia	good job; consent

Figure 10: Emoji sign #7.

Figure 11: Emoji sign #8.

substrate a psycho-emotional factor of sign perception. Thus, according to the results, we obtained the following disclosure: 70% of respondents of all categories explained the sign as "disease", "epidemic", "temperature". However, the answers of humanities teachers, as well as students aged 20 to 40, were typical. The signifier of the #8 sign of the mentioned respondents is "silence" or "I do not use". Representatives of exact and natural sciences mostly emphasized that the sign does not belong to their digital continuum (table 8).

The sign #9 (figure 12) is not characterized by popularity in use in computer being, therefore a priori it was placed for the purpose of revealing of differentiation of a lexical field of respondents that is projected on perceptual sensations.

Figure 12: Emoji sign #9.

A remarkable point is that the less popular (almost unknown emoji sign) was 100% interpreted unambiguously and with one (in this case – negative) connotation. This is important information, because popular characters have many semantic branches in recipients of different categories, which again confirms the open aposteriority of artificial emoji language with the emergence of new connotations in digital communication and expansion of the lexical field of the respondent (table 9).

The sign #10 (figure 13) in our experiment is the key optical sign in digital communication.

Figure 13: Emoji sign #10.

The sign is quite popular, however, as the results of the experiment showed, it is popular not for the denotation, but for the psycho-emotional characteristics of the respondent. 99% of respondents answered that the sign has a negative connotation and optically reflects the state of anger, rage and rage. In fact, this sign is mental in location – a sign of Japanese origin to express a sense of triumph (in Unicode Consortium – "Face with Look of Triumph"). Thus, we conclude that the mentioned mental frame was not read by computer science specialists, artists or connoisseurs of oriental languages. The sign was interpreted and perceived according to the universal psycho-emotional state – the state of anger, rage, anger (table 10).

The respondent who provided the only correct answer is a historian by profession. Hypothetically and deductively, we can conclude that in this case the emotional nature of the artificial language emoji prevailed, which, in fact, is one hundred percent embedded in the concept of Unicode Consortium. Correct disambiguation of this sign is an exception to appeal to the respondent's profession when it comes to text as information. For linguists the text was perceived as a structure for computer science specialists – a matrix, representatives of the exact sciences – hypothesis. Perceiving the text as information, the representative of the historical profession did not notice the emotional nature of the sign, relying in general on the information about this sign, which is its (sign) English name "Face with Look of Triumph".

The final stage of the survey was the question "Can emoji replace natural language?". In fact, the last question is an additional result of previous conclusions on the use of emoji in the pedagogical process, depending on the different categories of respondents. The results of the survey show the following picture: 5.5% (6 respondents) answered "Yes, in full"; 29.1% (32 respondents) – "50/50"; 59.1% (65 respondents) – "No, they can't" (figure 14).

Note that the answer "Yes, in full" belongs to the respondents, whose age category is mostly from 10 to 20 years, to a lesser extent – from 20 to 40 (students and teachers of philology and artists). In the first case, such results are explained by the nature of the humanities (mostly literary studies), where emoji is an a priori fact of the aposteriori continuum (for example, a work of fiction), and therefore is one hundred percent significant and signifier at the same time. In the second case, the object of fine art is essentially synonymous with emoji pictographic (visual, optical) result of creative activity.

The answer "50/50" belongs to philologists (linguistics), as well as representatives of sciences (economists), social sciences (psychologists), humanities (archaeologists, publishers). Philologists-linguists appeal to the nature of their profession, considering the text (including art) as a structure – in particular in syntagmatics and paradigmatics, and thus, this explains the interest in the differential verbalization of the polylateral emoji sign as an aprioriposteriori system of thinking (Makhachashvili and Bakhtina, 2019). Hypothetically, we explain the position of the representatives of economic sciences, appealing to the ergonomic ousia of language and speech resources in digital communication. In the case of the social sciences and humanities, a fundamental factor is the understanding of emoji as a sup-

Table 8: Generalized definitions of Emoji sign #8.

What does the following emoji mean to you?	In what context could you use it?
Quarantine	Warning or description of the current situation
I'm sick	I'm in a mask)))
I do not use	Mask on the face, silence
Coronavirus	Wearing a mask is mandatory, something related to the hospital
Laughter under a mask	COVID-19
I'm sick. But I would call such an emoji would not use	Self-isolation
I'm silent	Limitations of opportunities
I'm silent	I'm sick or I'd better keep quiet
She fell ill. But in the conditions of quarantine - observance of safety rules.	Someone is sick and has to SIT AT HOME. (obvious influence of recent events)
Keep your distance	I would have written earlier: I can't speak! now it is possible: we adhere to a mask mode. Didn't use this emoji.
Safety measures during the epidemic	I do not use this, but now it is relevant, fashionable to use as a reminder of protection

Table 9: Generalized definitions of Emoji sign #9.

What does the following emoji mean to you?	In what context could you use it?
Head turn	In alcohol intoxication
tired, broken, confused	This is my face every morning
Amazingly	I do not use it because it is disgusting
incomprehension	An unusual, extraordinary situation; uncertainty
"Hangover" / "sleep deprivation" – a reaction to questions about the condition	Expresses stupidity, play, intoxication
Fatigue, inability to concentrate	Confused
condition of students after the session	Crazy situation
I don't even know. when I swelled dumplings...	I have never seen such a thing, he is a bit drunk

Table 10: Generalized definitions of Emoji sign #10.

What does the following emoji mean to you?	In what context could you use it?
Malice	Lots of work, boring, maybe annoying
Malice	"evil", "dissatisfied", "not in humor", "offended"
I'm angry	I'm outraged
Fatigue	I would kill!
Very emotional	Horror
I'm boiling	the last stage before anger, I can barely restrain myself from breaking
Anger, resentment, but again, I would use it to denote my reactions in not very serious situations. In addition, I read that this smiley is not an expression of dissatisfaction, but has a different connotation, but for me it is an expression of these emotions.	"God forbid she's still something" XD (stock up on patience)
Dissatisfaction, anger, the tram was late	overflowing with negative emotions, I want to let off steam

plement to the basic layer of information in digital communication.

The answer "No, they can't" belongs more to the humanities, in particular to philologists, whose age category is from 40 to 60, as well as 66 years. This is probably explained by the temporal limits of the emergence of the digital continuum in the former Soviet republics, which in the long run prolonged the universality, ideality and completeness of natural languages.

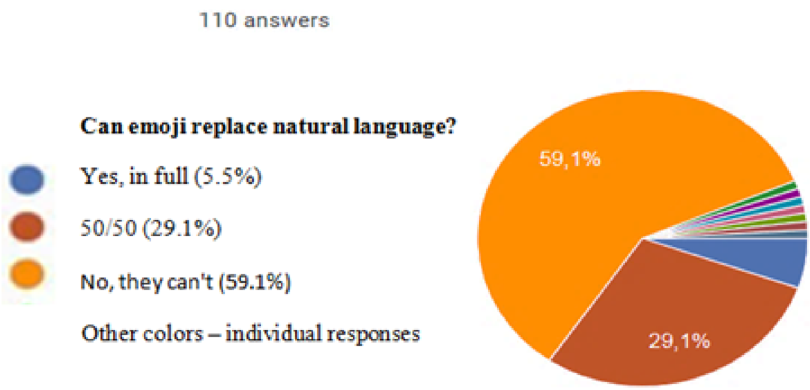

Figure 14: Interchangeability of emoji sign system and natural language.

A big surprise was the position of computer science specialists, which expresses the impossibility of artificial languages (including emoji) to be a substitute for natural. We have already emphasized this unexpectedness above. Thus, we finally conclude that computer science specialists, studying language as a digital palindrome and an atemporal matrix, classify emoji as a loglan, which a priori cannot have an emotional substrate. 7 out of 110 respondents expressed a desire to express their opinion on the question "Can emoji replace natural language?":

1. *They can only supplement / diversify.*
2. *Replace no, but they give the correspondence cool emotions. One emoji can convey your mood.*
3. *It is only a supplement to the written conversation, although it can be a substitute for emotions in the same conversation.*
4. *For me, emoji is more of a complement to ordinary language, but not a replacement for it. It's like a picture book. Without pictures it is not so colorful and fun.*
5. *They create an analog language, but natural language is better, because you can operate live with a newly created expression of emotions. Emoji create boundaries within which you can express yourself, but it is often impossible to find an exact match for your emotions.*
6. *Partly, but it is worth the vicinity ' favorites, each emoji treated every person differently. And this can lead to misunderstandings. And natural language cannot be completely replaced, it is rather a supplement to the expression of emotions.*
7. *To some extent. But some have already replaced* ☺

The respondents' detailed answers were subject to digital content analysis via an open source Voyant corpus/text mining toolkit (https://voyant-tools.org/). Two instruments were used specifitaly for 1) key words identification (quantitavely calibrated word cirrus, featuring foregrounded concepts and notions) – figure 15, and 2) key words frequency estimation (key words trending in the horizontally segmented corpus of responses) – figure 16. The key words of the respondents' detailed answers in equal proportions are "language", "emotions", "emoji", "expression", which hypothetically appeals to the conceptualiazation of natural languages as perfect, and therefore artificial languages, in particular emoji, are an optical supplement to the expression of a particular context. Consequently, emoji becomes not so much an artificial language as a form of language, a frame of writing that enhances and / or explains human feelings and emotions, but at the same time can create misunderstandings of the explication of the signifier, which depends on many factors: conditions, modality of expression etc.

Figure 15: Digital content analysis: calibrated word cirrus.

All the stated above, given the specifics of the respondents' answers, allows to conclude that in terms of expression emoji is not an independent language. Despite a clear and logical algorithm for generating and codifying artificial language in computer being,

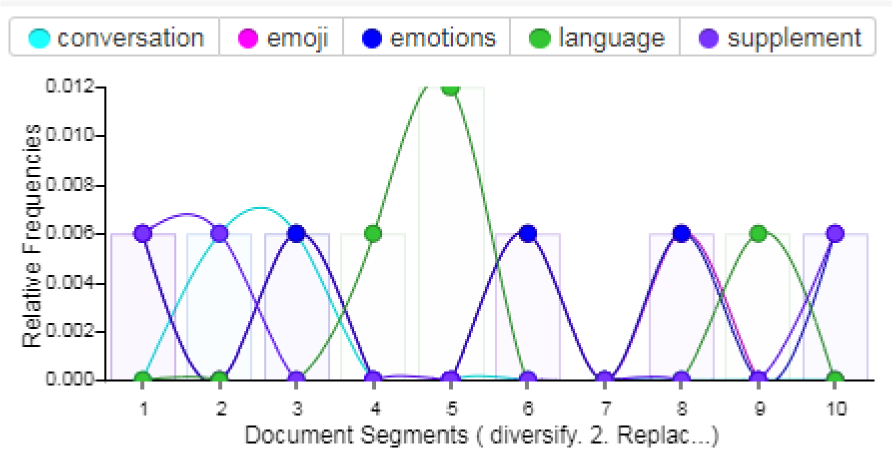

Figure 16: Digital content analysis: key words frequency.

the perception and interpretation of a particular emoji sign varies depending on its use by a particular person. However, it is this feature of the emoji language that involves updating the content and form of academic writing in the pedagogical educational process with the involvement of the ICT generated and implemented emoji language in a specific context. After all, the use of graphic signs will promote the development of visual (photographic) memory in students, as well as the development of emotional intelligence (EQ), necessary for awareness and understanding of one's own emotions and the emotions of others. According to theory of Bar-On (Bar-On, 2010), emotional intelligence is defined as a set of various abilities that provide the ability to act successfully in any situation (Goleman, 2005). In addition, under lockdown through COVID-19 timespan, the use of emoji in the pedagogical process can prevent stressful situations, and therefore provide for better and more effective learning, because emotional intelligence involves the activation of the following functions: interpretive, regulatory, adaptive, stress-protective, activational.

Thus, summarizing all the empirical data collected through the survey, we can trace the effectiveness of the use of artificial languages in the pedagogical process, taking into account the specifics of the professional activities of the respondent. However, we should note that, summarizing the experimental data, we get another question: why use the emoji language in the pedagogical process? As the survey showed, emoji are an integral part of modern digital communications. Moreover, the digitalization of the educational process by its nature appeals to the codification of the semantic field of the communicative act. Therefore, we consider emoji not so much a new as a newer, modernized format of the sign system, which allows different systems in its structure (cuneiform – hieroglyphics – Morse code) in digital communication.

4 CONCLUSIONS AND PROSPECTS OF FURTHER RESEARCH

Through an experiment, which consisted of surveying participants in the educational process, we concluded the following:

1. Artificial digital emoji language reproduces polylaterality in structure (elements of sign generation) and semantics (multi-vector perception and interpretation of the sign). This explains the scale of differentiation of emoji signs, taking into account mental frames and universal characteristics at the same time.
2. The polylateral perception and interpretation of emoji depends on the speaker, which the team of authors classified in the study into the following categories:
   - Age
   - Profession
   - Knowledge of foreign languages
   - Choice of social networks.

First of all, our empirical experiment was created for teachers and educators in the pedagogical field. This would allow us to trace the speed and direction of the process of introduction of the digital continuum into the pedagogical activity (artificial languages, in particular emoji) in order to identify the feasibility and effectiveness of learning at the intersection of natural and artificial languages and digital communication. However, representatives of other professions also joined the experiment: computer science specialists, economists, artists, poets and prose writers, which gave us the opportunity to expand the subject of our study, appealing not only to antithetical professions (humanities and sciences), but also to the nature and specifics of each profession. The latter, in turn, is encoded in the structure of the speaker thought by mental frames that professional experience generates a verbal language system and speaking respondents and ideographic optical pattern embedded in the artificial language of books existence – language emoji.

According to the results of the experiment, we also conclude that 100% of respondents (110 people) use emoji both in everyday life and in professional activities. Although, the ousia of emoji in digital communication has significant shades of meaning for each profession (not excluding age and language skills). Thus, the representatives of the humanities and social sciences when using emoji appeal to the psycho-emotional load of the sign, considering it as a supplement to the text in order to express emotions in digital communication. Therefore, emoji for these representatives can replace natural language for the most part by 50%, as evidenced by the experiment to reproduce the content of poetry on the basis of EmojiMaker platform (Makhachashvili et al., 2020).

Only a small percentage of respondents are convinced of the equivalent replacement of natural language with artificial. Such respondents include philologists and linguists. However, it should be emphasized that it was linguists who provided detailed answers regarding the perception and interpretation of emoji signs, which confirms the vision of the emoji language as an a priori-a posteriori system. Consequently, emoji can be both a supplement to the main text and an independent language with a full reproduction of meaning.

Representatives of sciences (mathematicians, economists, programmers) consider emoji as an independent language to the least extent, the explication of which is the frame P-semantics of the thinking structure of the representatives of the specified professions, which is as follows. For the outlined speakers, the auxiliary element of the effectiveness of their professional activity is the natural language itself, which a priori puts artificial languages in the position of auxiliary symbols to obtain the result of work in the form of digital content and matrix grid. Therefore, most of the exact sciences use emoji, without giving clear and unambiguous connotations to the sign during digital communication.

In further research it is necessary to expand the classification of respondents by professional activity even more, involving the following representatives in the experiment:

1. Teachers: specialists in physics, biology, law, political science and others who were not involved in the experiment.
2. Non-teachers: other professions that are not related to educational and pedagogical activities.

Such scale and heterogeneity of respondents will allow to outline Gaussian with normal (statistical) distribution of emoji language ousia, fractalizing the effect of the exponential function of artificial language onto a quadratic function. Thus, we will have a deductive hypothesis of the role, function and impact of emoji language on teachers and non-teachers, which will trace the advantages and disadvantages of digitalization of society both in the educational process and outside its framework. In addition, this approach appeals to the selection of the third subject of study – the linguistic construction of individual "Sprachspiel" (term by Wittgenstein (Wittgenstein, 2007)) using natural and artificial languages with an emphasis on the apriori-posteriori nature of emoji in digital communication.

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Guessing Games Experiments in Ukraine: Learning towards Equilibrium

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Abstract: The paper deals with experimental game theory and data analysis. The research question, formulated in this work, is how players learn in complex strategic situations which they never faced before. We examine data from different games, played during lectures about game theory and present findings about players progress in learning while competing with other players. We proposed four "pick a number" games, all with similar-looking rules but very different properties. These games were introduced (in the body of scientific popular lectures) to very different groups of listeners. In this paper we present data gathered during lectures and develop tool for exploratory analysis using R language. Finally, we discuss the findings propose hypothesis to investigate and formulate open questions for future research.

1 INTRODUCTION

Game theory is a field of science which investigates decision-making under uncertainty and interdependence, that is, when the actions of some players affect the payoffs of others. Such situations arise around us every day and we, consciously or unconsciously, take part in them and try to succeed. The struggle to achieve a better result (in some broad sense) is called rationality. Every rational player must take into account the rules of the game, the interests and capabilities of other participants in other words think strategically. Game theory provides a tool for analyzing such situations, which allows you to better understand the causes of conflicts, learn to make decisions under uncertainty, establish mutually beneficial cooperation and much more.

A key element of strategic thinking is to include into consideration what other agents do. Agent here is a person, who can make decisions and his/her actions have influence on the outcome. Naturally, person cannot predict with 100% what will others do, so it is important to include into model beliefs about other person thinking and update them during the game. Also, if we can't know what other player think, we can understand what is his/her best course of action. This is the main research topic of game theory.

All this makes decision making very interesting problem to investigate. In this work we will apply game theory to analyze such problems. Game theory provides mathematical base for understanding strategic interaction of rational players. There is important note about rationality, we should make. As Robert Aumann formulate in his famous paper (Aumann, 1985), game theory operates with "homo rational", ideal decision maker, who is able to define his/her utility as a function and capable of computing best strategy to maximize it. This is the main setup of game theory and one of major lines of criticism. In reality, of course, people are not purely rational in game theory sense. They often do not want to concentrate on a given situation to search for best decision or simply do not have enough time or capabilities for this. Sometimes they just copycat behavior of others or use some cultural codes to make strange decisions. Also (as we see from the experiments) it seems that sometimes homo sapiens make decisions with reasons, one can (with some liberty in formulation) label as "try and see what happens", "make random move and save thinking energy" and even "make stupid move to spoil game for others".

This is rich area of research, where theoretical constructions of game theory seems to fail to work and experimental data shows unusual patterns. However, these patterns are persistent and usually do not depend on age, education, country and other things. During last 25 years behavioral game theory in numerous studies examines bounded rational-

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ity (best close concept to rationality of game theory) and heuristics people use to reason in strategic situations. For example we can note surveys of Crawford et al.; Mauersberger and Nagel (Crawford et al., 2013; Mauersberger and Nagel, 2018). Also there is comprehensive description of the field of behavioral game theory by Camerer (Camerer, 2011).

Also we can note work of Gill and Prowse (Gill and Prowse, 2016), where participants were tested on cognitive abilities and character skills before the experiments. Then authors perform statistical analysis to understand the impact of such characteristics on the quality of making strategic decisions (using p-beauty contest game with multiple rounds). In more recent work of Fe et al. (Fe et al., 2019) even more elaborate experiments are presented. It is interesting that in the mentioned paper experiments are very strict and rigorous (as close to laboratory purity as possible) in contrast to games, played in our research. But in the end of the day the results are not differ very much.

The guessing games are notable part of research because of their simplicity for players and easy analysis of rules from game theoretic prospective. In this paper we present results of games played during 2018–2020 years in series of scientific popular lectures. The audience of these lectures was quite heterogeneous, but we can distinguish three main groups:

- kids (strong mathematical schools, ordinary schools, alternative education schools);
- students (bachelor and master levels);
- mixed adults with almost any background;
- businessmen;
- participants of Data Science School.

We propose framework of four different games, each presenting one idea or concept of game theory. These games were introduced to people with no prior knowledge (at least in vast majority) about the theory. From the other hand, games have simple formulation and clear winning rules, which makes them intuitively understandable even for kids. This makes these games perfect choice to test ability of strategic thinking and investigate process of understanding of complex concepts during the play, with immediate application to the game. This dual learning, as we can name it, shows how players try-and-learn in real conditions and react to challenges of interaction with other strategic players.

1.1 Game Theory Definitions

We will consider games in strategic or normal form in non-cooperative setup. A non-cooperativeness here does not imply that the players do not cooperate, but it means that any cooperation must be self-enforcing without any coordination among the players. Strict definition is as follows.

A non-cooperative game in strategic (or normal) form is a triplet $G = \{\mathcal{N}, \{S_i\}_{i=\in\mathcal{N}}, \{u_i\}_{i\in\mathcal{N}}\}$, where:

- $\mathcal{N}$ is a finite set of players, $\mathcal{N} = \{1,\ldots,N\}$;
- S_i is the set of admissible strategies for player i;
- $u_i : S \to \mathcal{R}$ is the utility (payoff) function for player i, with $S = \{S_1 \times \cdots \times S_N\}$ (Cartesian product of the strategy sets).

A game is said to be static if the players take their actions only once, independently of each other. In some sense, a static game is a game without any notion of time, where no player has any knowledge of the decisions taken by the other players. Even though, in practice, the players may have made their strategic choices at different points in time, a game would still be considered static if no player has any information on the decisions of others. In contrast, a dynamic game is one where the players have some (full or imperfect) information about each others' choices and can act more than once.

Summarizing, these are games where time has a central role in the decision-making. When dealing with dynamic games, the choices of each player are generally dependent on some available information. There is a difference between the notion of an action and a strategy. To avoid confusions, we will define a strategy as a mapping from the information available to a player to the action set of this player.

Based on the assumption that all players are rational, the players try to maximize their payoffs when responding to other players' strategies. Generally speaking, final result is determined by non-cooperative maximization of integrated utility. In this regard, the most accepted solution concept for a non-cooperative game is that of a Nash equilibrium, introduced by John F. Nash. Loosely speaking, a Nash equilibrium is a state of a non-cooperative game where no player can improve its utility by changing its strategy, if the other players maintain their current strategies. Of course players use also information and beliefs about other players, so we can say, that (in Nash equilibrium) beliefs and incentives are important to understand why players choose strategies in real situations. Formally, when dealing with pure strategies, i.e., deterministic choices by the players, the Nash equilibrium is defined as follows:

A pure-strategy Nash equilibrium (NE) of a non-cooperative game G is a strategy profile $s' \in S$ such that for all $i \in \mathcal{N}$ we have the following inequality:

$$u_i(s'_i, s'_{-i}) \geq u_i(s_i, s'_{-i})$$

for all $s_i \in S_i$.

Here $s_{-i} = \{s_j | j \in \mathcal{N}, j \neq i\}$ denotes the vector of strategies of all players except i. In other words, a strategy profile is a pure-strategy Nash equilibrium if no player has an incentive to unilaterally deviate to another strategy, given that other players' strategies remain fixed.

1.2 Guessing Games

In early 90xx Rosemary Nagel starts series of experiments (Mitzkewitz and Nagel (Mitzkewitz and Nagel, 1993)) of guessing games, summarized in (Nagel, 1995). She wasn't the first one to invent the games, it was used in lectures by different game theory researchers (for example Moulin (Moulin, 1986)). But her experiments were first experimental try to investigate the hidden patterns in the guessing game. Ho et al. (Ho et al., 1998) gave the name "p-beauty contest" inspired by Keynes (Keynes, 1936) comparison of stock market instruments and newspaper beauty contests. This is interesting quote, so lets give it here: "To change the metaphor slightly, professional investment may be likened to those newspaper competitions in which the competitors have to pick out the six prettiest faces from a hundred photographs, the prize being awarded to the competitor whose choice most nearly corresponds to the average preferences of the competitors as a whole; It is not a case of choosing those which, to the best of one's judgment, are really the prettiest, nor even those which average opinion genuinely thinks the prettiest. We have reached the third degree where we devote our intelligence to anticipating what average opinion expects the average opinion to be. And there are some, I believe, who practice the fourth, fifth and higher degrees." (Keynes, 1936, chapter 12.V).

The beauty contest game has become important tool to measure "depth of reasoning" of group of people using simple abstract rules. Now there are variety of rules and experiments presented in papers, so lets only mention some of them.

2 EXPERIMENTS SETUP

The setup is closer to reality then to laboratory and this is the point of this research. All games were played under following conditions:

1. Game were played during the lecture about the game theory. Participants were asked not to comment or discuss their choice until they submit it. However, this rule wasn't enforced, so usually they have this possibility if wanted;
2. Participants were not rewarded for win. The winner was announced, but no more.
3. During some early games we used pieces of paper and we got some percentage of joking or trash submission, usually very small. Later we have switched to google forms, which is better tool to control submission (for example only natural numbers allowed).
4. Google forms gives possibility to make multiple submission (with different names), since we didnt have time for verification, but total number of submission allows to control that.

The aim of this setup was to free participants to explore the rules and give them flexibility to make decision in uncertain environment. We think it is closer to real life learning without immediate rewards then laboratory experiments. Naturally, this setup has strong and weak sides. Lets summarize both.

The strong sides are:

1. This setup allow to measure how people make decisions in "almost real" circumstances and understand the (possible) difference with laboratory experiments;
2. These games are part of integrated approach to active learning, when games are mixed with explanations about concepts of game theory (rationality, expected payoff, Nash equilibrium etc), and they allow participants to combine experience with theory;
3. Freedom and responsibility. The rules doesn't regulate manipulations with conditions. So this setup allows (indirectly) to measure preferences of players: do they prefer cheat with rules, just choose random decision without thinking or put efforts in solving the task.

Weak sides are:

1. Some percentage of players make "garbage" decisions. For example choose obviously worse choice just to spoil efforts for others;
2. Kids has (and often use) possibility to talk out decision with the neighbors;
3. Sometimes participants (especially kids) lost concentration and didn't think about the game but made random choice or just didn't make decisions at all;
4. Even for simplest rules, sometimes participants failed to understand the game first time. We suppose it is due to conditions of lecture with (usually) 30-40 persons around.

2.1 Rules

All games have the same preamble: Participants are asked to guess integer number in range 1 – 100, margins included. Note, that many setups, investigated in references, use numbers starting with 0. But the difference is small.

To provide quick choice calculation we have used QR code with link to google.form, where participants input their number. All answers were anonymous (players indicate nicknames to announce the winners, but then all records were anonymized). The winning condition is specific for every game.

1) p-beauty contest. The winning number is the closest to 2/3 of average;
2) Two equilibrium game. The winning number is the furthest from the average;
3) Coordination with assurance. The winning number is the number, chosen by plurality. In case of tie lower number wins;
4) No equlibrium game. The winning number is the smallest unique.

All these games are well-known in game theory. Lets briefly summarize them. First game is dominance-solvable game. Strategy “to name numbers bigger then 66” is (weakly) dominated, since it is worse then any other for almost all situations and equal in the rest. So rational player will not play it and everybody knows that. Then second step is to eliminate all numbers higher then 44 and so on. At the end rational players should play 1 and all win. In our setup we go further then just give players learn from observation. After first round we explain in detail what is Nash equilibrium and how it affect the strategies. After this explanation all participants actually knew that choosing 1 is the equilibrium option, when everyone wins. We supposed, that this should help to improve strategies in next round, but it is not.

Second game is about mixed strategies. Easy to show that if you want to choose number smaller then 50 – best way is to choose 1, since all other choices are dominated. And if you want to choose number bigger then 50 – best idea is to choose 100. Also it is meaningful to choose 50 – it almost never wins. So if many players will choose 1 – you should choose 100 and visa versa. In this game the best way to play is literally drop a coin and choose 1 or 100.

Third game has many equilibria, basically every number can be winning. But to coordinate players must find some focal points (Schelling (Schelling, 1960)). Natural focal point (but not only one!) is the smallest number since smaller number wins in case of tie. This slim formulation allow nevertheless make successful coordination in almost all experiments.

Finally last game is in a dark waters. As far as we know there is no equilibrium or rational strategy to play it. So sometimes very strange numbers are winners here.

3 RESULTS AND DATA ANALYSIS

In this section we present summary of data, gathered during the games.

3.1 First Game

Summary of results of First game is given in the table 1.

Almost all winning numbers are fall (roughly) in the experimental margins, obtained in Nagel (Nagel, 1995) work. With winning number no bigger then 36 and not smaller then 18 in first round. Two exceptions in our experiments were Facebook on-line test (15.32), when players can read information about the game in, for example, Wikipedia. And other is alternative humanitarian school (40.1), where participants seems didn’t got the rules from the first time.

Using R statistical visualization tool we can analyze in details how players from different types change their decisions between first and second round (figure 1).

3.1.1 Metrics and Analysis

Interesting metric is the percent of “irrational choices” – choices that can’t win in (almost) any case. Lets explain, imagine that all players will choose 100. It is impossible from practice but not forbidden. In this case everybody wins, but if only one player will deviate to smaller number – he/her will win and others will lose. So playing numbers bigger then 66 is not rational, unless you don’t want to win. And here we come to important point, in all previous experiments this metric drops in second round and usually is very low (like less than 5%) (Ho et al., 1998). But in our case there are experiments where this metric become higher or changes very slightly. And initially values are much higher then expected. So here we should include factor of special behavior, we can call it “let’s show this lecturer how we can cheat his test!”. What is more interesting – this behavior more clear in case of adult then kids.

It is also interesting to see distribution of choices for different types of groups. We can summarize choices on the histograms (figure 2). Using models of

Table 1: Summary of first game for types of players.

Type	Round	Average	Winning	Median	Count	Irrationality
Adults	1	40.6	27	40	19	10.5
Adults (facebook online)	1	22.98	15.32	17	102	4.9
Alternative humanitarian	1	60.2	40.1	63	24	45.8
Alternative humanitarian	2	9.67	6.44	4	24	4.17
Alternative humanitarian	3	3.08	2.05	2	13	0
Alternative mathematical	1	41.9	27.9	42	35	17.1
Alternative mathematical	2	20.7	13.8	18	33	0
Business	1	44.4	29.6	41	65	27.7
Business	2	14.1	9.43	12	99	1.01
DS conference attendees	1	35.6	23.7	32.5	142	12.0
DS conference attendees	2	15.9	10.6	9	148	6.08
Math lyceum	1	37.7	25.1	33	148	14.2
Math lyceum	2	19.2	12.8	13	106	4.72
MS students	1	39.0	26.0	30	35	20
MS students	2	8.6	5.75	8.5	8	0
Ordinary school	1	48.7	32.5	46.5	26	23.1
Ordinary school	2	19.8	13.2	22	23	0
Tech School	1	43.4	28.9	45	51	23.5
Tech School	2	46.5	31.0	29	62	33.9

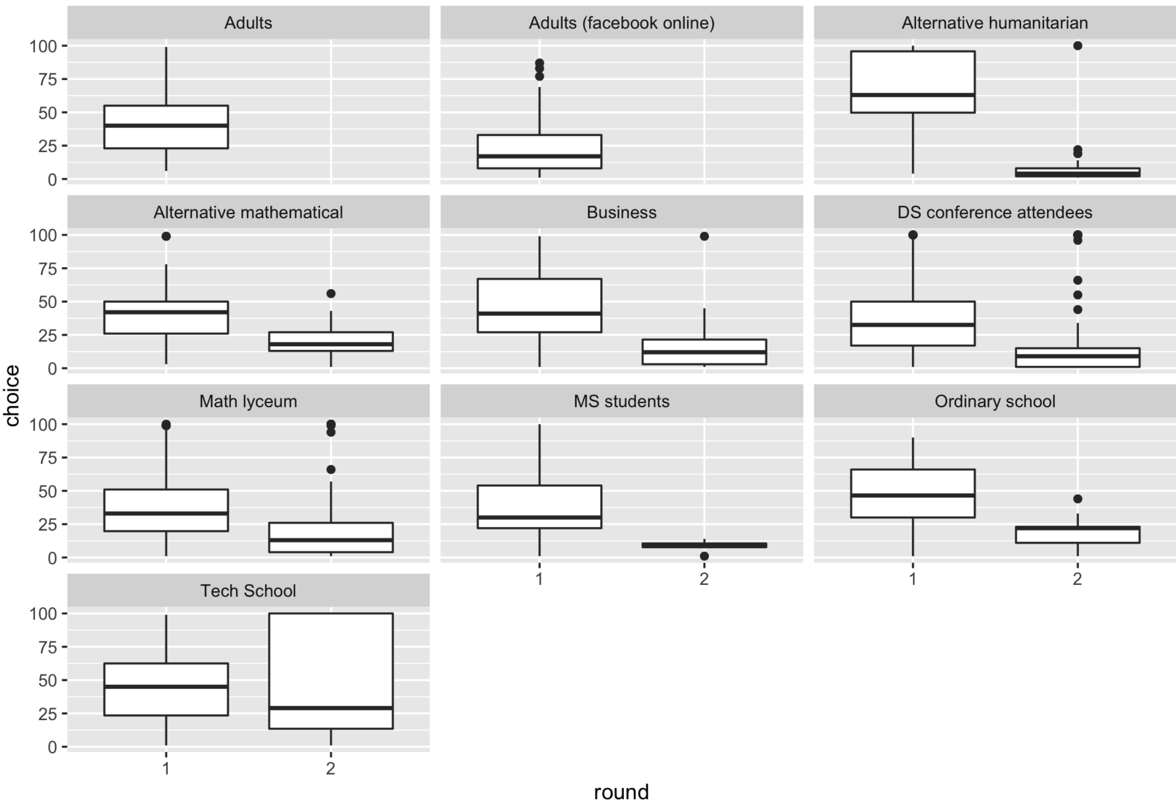

Figure 1: Graphical representation of learning between rounds.

strategic thinking we will adopt the theory of k-levels. According to this idea 0-level reasoning means, that players make random choices (drawn from uniform distribution), and k-level reasoning means that these players use best-response for reasoning of previous level. So 1-level reasoning is to play 33, which is best response to belief that average will be 50, 2-level is best response to belief that players will play 33 and so on.

Highlighting first 4 levels with dotted lines is a good idea, it is showing hidden patterns in strategy choosing of players.

As we can see from the diagram 2, some spikes in choices are predicted very good, but it depends on the background of players. The best prediction is for attendees of Data Science conference, which presumes high level of cognitive skill and computer science background.

Next two figures show the learning process from different angles. On figure 3 we can see points, defined by number of players with 0-level and "irrational" (choices with big numbers) versus "too smart" choices – choices from [1,5], which is not good for first round. The players, who choose small rounds probably knew about this game or they thought that everyone are as smart as they are. It is also possible, that some part of them were 0-level players, who just pick small number randomly. In any case, we can see two distinct clusters: first round (round dots) and second round (triangles). The explanation about equilibrium concept created this transition in choices, when choices from [50,100] decreasing, and choices from [1,5] increasing.

Interesting hypotheses, that need to be tested in details, can be formulated: **Higher number of choices from [50,100] in first round leads to higher number of choices from [1,5] in second round and vice verse.**

Another metric (Güth et al., 2002) is how much winning choice in second round is smaller then in first. Due to concept of multi-level reasoning, every player in this game trying to its best to win but cant do all steps to winning idea. So there are players, who just have 0-level reasoning, they choose random numbers. First-level players choose 33, which is best response for players of 0-level and so on. Based on result of first round and, in fact, explanation about the Nash equilibrium, players must know that it is better to choose much lower numbers. But graph shows that decrease is quite moderate. Only students shows good performance in this matter. And tech school shows increase in winning number in second round! (figure 4)

3.1.2 Levels of Reasoning Analysis

Another point about the process of learning in this game is how players decision are distributed over the space of strategies. We claim that there is distinct difference in changes between first and second round for different groups. To perform this analysis we apply the idea of k-level thinking.

To find differences we need to simplify this approach. First, we define **b-level** players players who choose numbers from the range [50,100]. It is beginner players, who do not understand rules (play randomly) or do not expect to win or want to loose intentionally (for reasons discussed above). The substantiation for such range is that numbers higher then 50 did not win in any game. Second level we call **m-level**, it is for range [18,50]. It is for players with middle levels of reasoning, usually first round winning number is in this range (and in part of second rounds also).

Third level is **h-level**, it is for range [5, 18]. It is for high level reasoning and finally **inf-level** ([1,5] range) is for "almost common knowledge" level of thinking.

Calculating the number of levels for each game we can estimate change (in percentage of number of players) in adopting different strategy levels.

There are some limitation of this approach:

- number of players changed with rounds, since not everyone participated (it was option, not obligation);
- limits of ranges are not defined by model or data. It can be future direction of research – how to define levels in best way.

Results are presented in table 2.

What conclusions we can draw from this data? There are no clear difference in changing, but at least we can summarise few points:

- Usually after first round and equilibrium concept explanation there is decrease in **b-level** and **m-level**;
- Symmetrically, there is increase in two other levels, but sometimes it is more distributed, sometimes it is (almost) all for **inf-level**;
- Last situation is more likely to happen in schools, were kids are less critical to new knowledge;
- Usually second round winning choice in the realm of **h-level**, so groups with biggest increase in this parameter are the ones with better understanding.

3.1.3 Size and Winning Choice

This game is indeed rich for investigation, let us formulate last (in this paper) finding about this game.

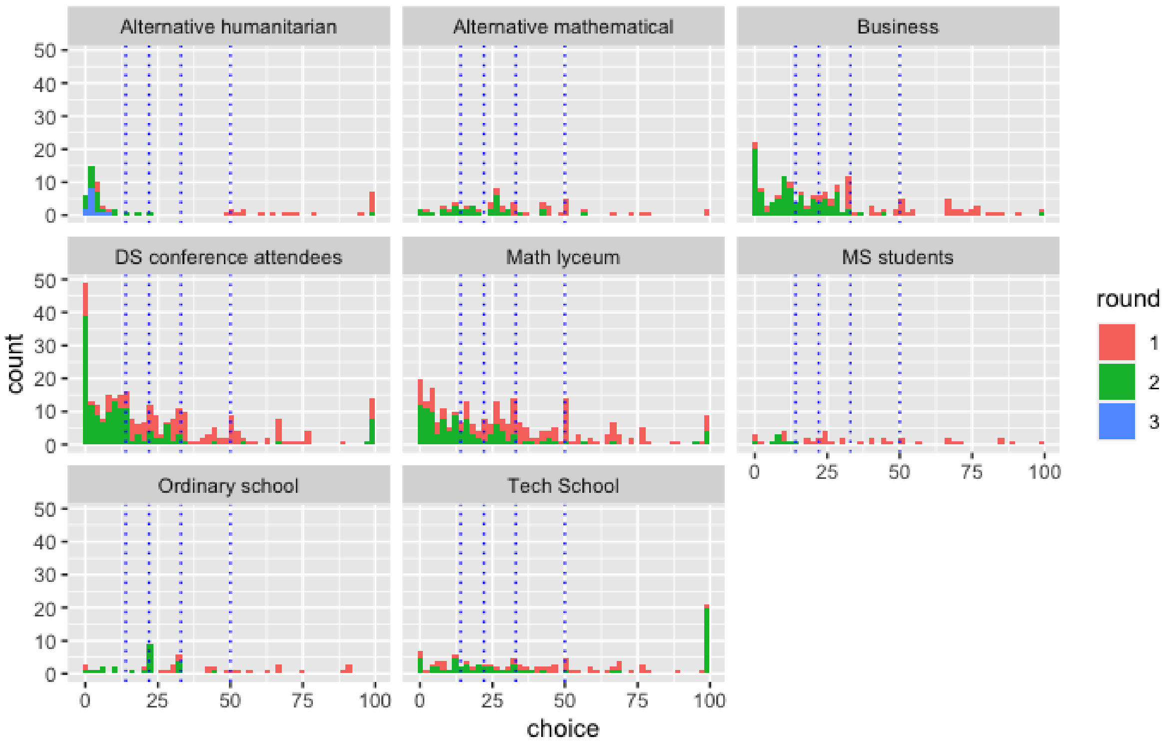

Figure 2: Histogram of choices for each round.

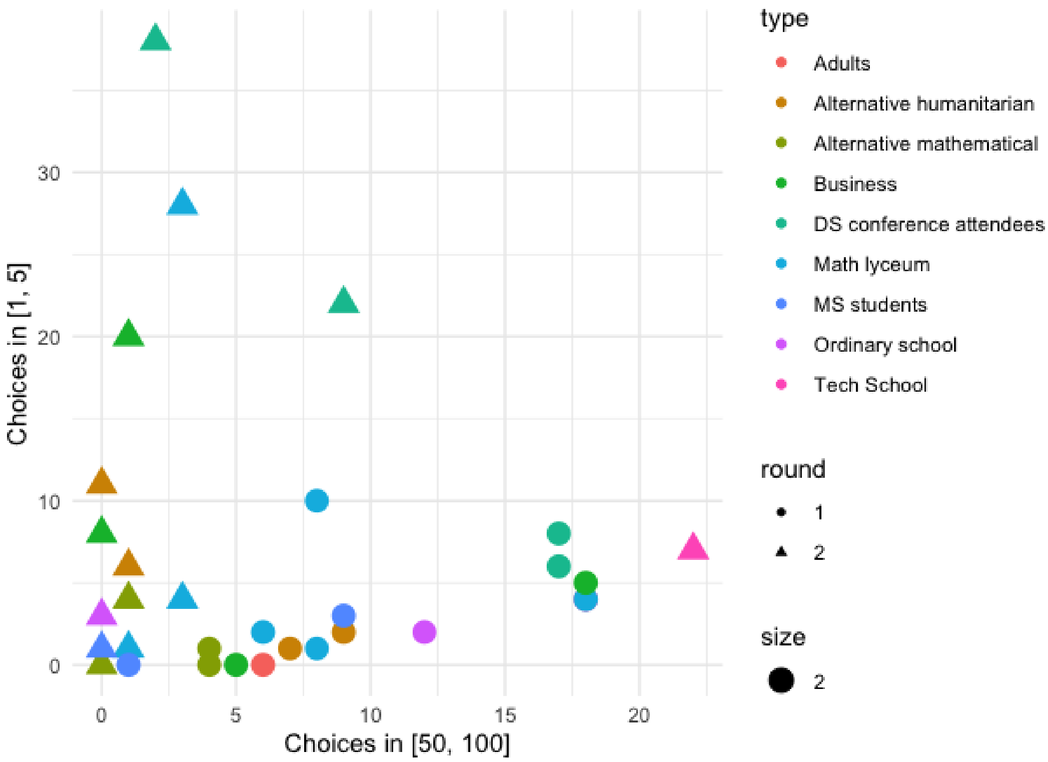

Figure 3: Comparing choices for different levels.

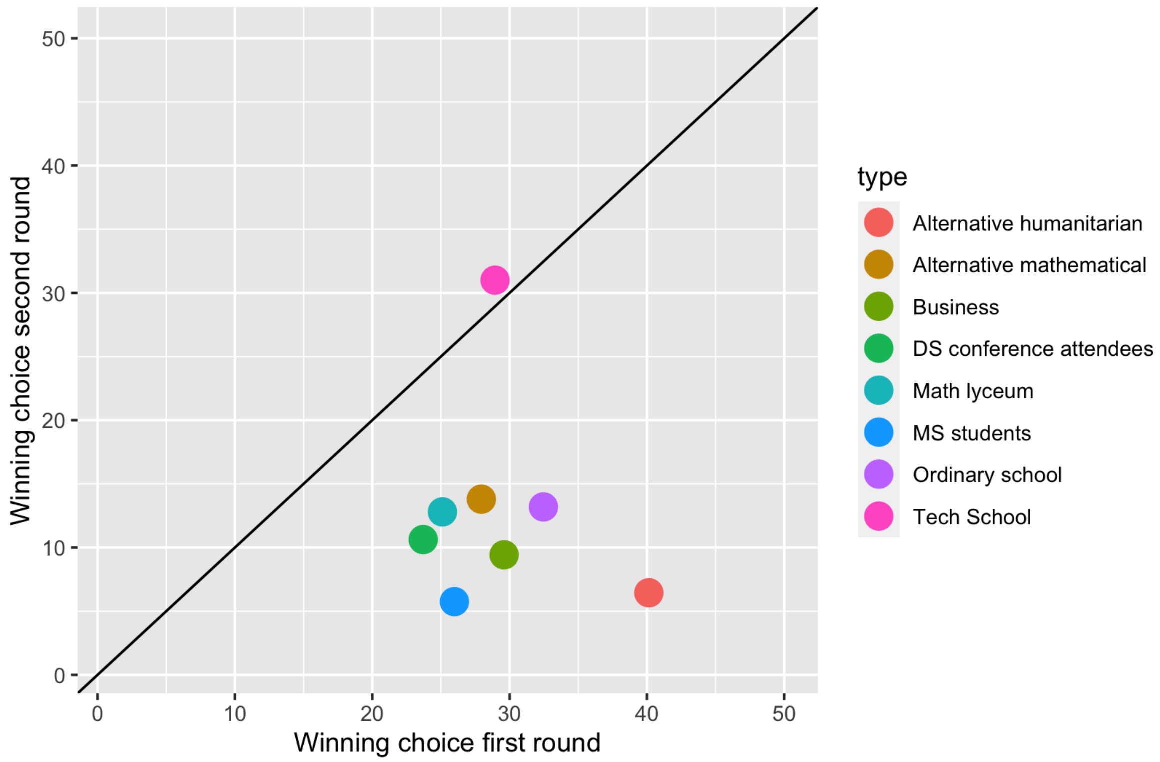

Figure 4: Change in winning number for rounds.

Table 2: Summary of change in strategy levels.

Type	b-difference	m-difference	h-difference	inf-difference
Alternative humanitarian	-72	-8	0	72
Alternative mathematical	-24	-6	30	-6
Alternative humanitarian	-52	0	17	43
Math lyceum	-9	-36	24	34
Math lyceum	-10	-24	28	7
Ordinary school	-49	12	20	4
DS conference attendees	-14	-32	14	27
MS students	-12	-50	50	12
Alternative mathematical	-17	-34	23	23
DS conference attendees	-17	-30	23	35
Business	-32	-17	21	28

Can we in some way establish connection between number of players and winning number (actually with strategies, players choose during the game)? To clarify our idea see at 5. It is scatter plot of two-dimensional variable, x-axis is for number of participants in the game and y-axis is for winning choice per round. Different color are for different types of group, where games was played.

Summarise findings about this plot:

- First and second rounds form two separate clusters. This is expected and inform us that players learned about the equilibrium concept between rounds and apply it to practice;
- There are two visible groups inside each round – undergraduates (schoolchildren, masters) and adults. Inside each group there is mild tendency that bigger group has bigger winning number.

This is yet too bold to formulate connection between size of the group and winning number, but probably the reason is that when size of the group is bigger, number of "irrational" players increases. It can be due to some stable percentage of such persons in any group or other reasons, but it is interesting connection to investigate.

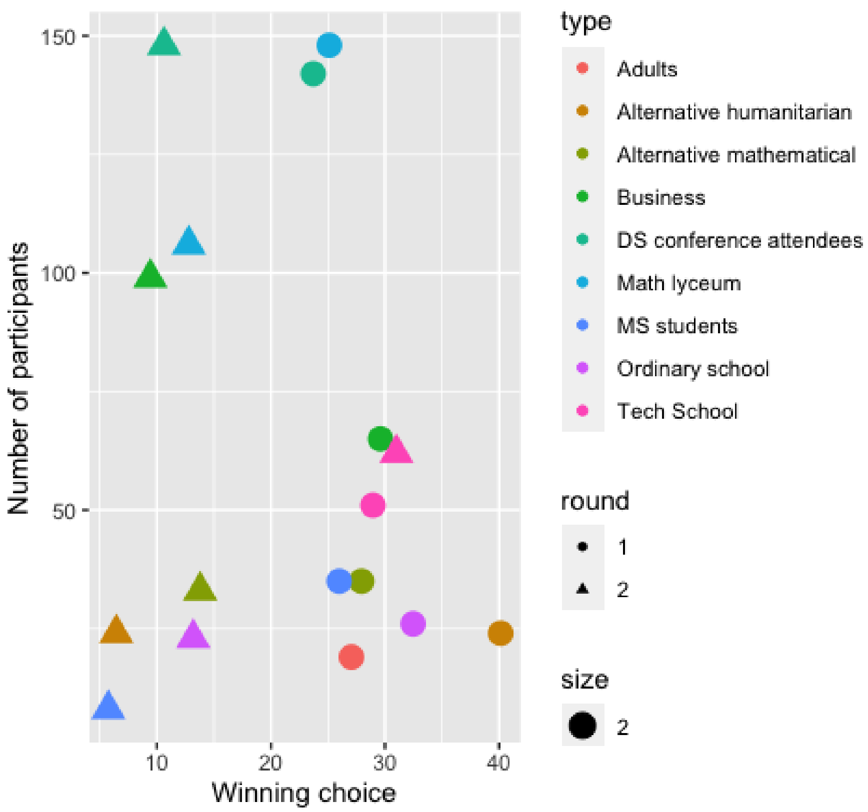

Figure 5: Change in winning number for rounds.

3.2 Second Game

In second game the key point is to understand that almost all strategies are dominated. The results are presented on figure 6 and we can see that average can be bigger or smaller then 50, and accordingly winning choice will be 1 or 100. It is worth to note, that popular nature of these experiments and freedom to participate make the data gathering not easy. For example many participants just didn't take any decision in second game. Results are summarised in the table 3.

We refine players decisions to see how many players made choices with rationalizability (Bernheim (Bernheim, 1984)), which are best response for some strategy profile of other players. In this game there are only two best responses possible (in pure strategies), literally 1 and 100.

This is remarkable result, players without prior communications choose to almost perfect mixed equilibrium: almost the same percentage choose 1 and 100. This is even more striking taking into account no prior knowledge about mixed strategies and mixed equilibrium, kids play it intuitively and without any communication. To illustrate the mixed Nash learning by groups, put dependency of percent of 1 choices and 100 choices on plot (figure 7).

3.3 Third Game

Third game is simpler then first two, it is coordination game where players should coordinate without a word. And, as predicted by Schelling (Schelling, 1980), they usually do. Date presented on figure 8 shows that 1 is natural coordination point, with one exception – Tech school (id = 1 here) decided that it would be funny to choose number 69 (it was made without single word). Probably, it is the age (11th grade) here to blame. Also we can note attempt to coordinate around 7, 50 and 100.

Interesting and paradoxical result, which is expected from general theory, that with fewer options coordination in fact is more difficult. Lets consider (figure 9), where players decision was to choose integer from [1,10], only 10 choices. Comparing to previous game with 100 possible choices, coordination was very tricky – two numbers got almost the same result.

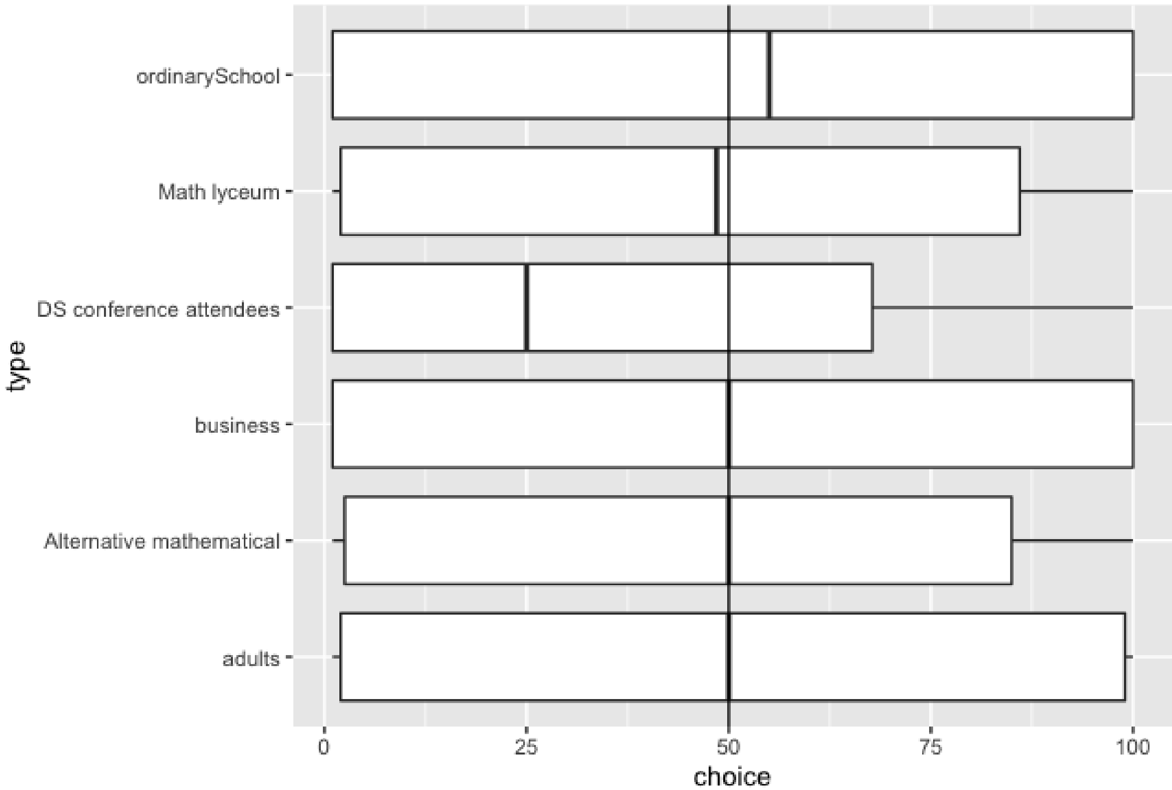

Figure 6: Statistics for choices.

Table 3: Second game. Rationalizable choices summary.

Type	Average	Choose 100	Choose 1	Count
Adults	46.5	24.3%	24.34%	115
Alternative mathematical	43.8	25.9%	27.9%	27
Business	50.6	29.3%	29.3%	99
DS conference attendees	37.4	15.8%	36.8%	114
Math lyceum	48.5	22.7%	24.7%	154
Ordinary school	51.2	30.4%	30.4%	23

3.4 Fourth Game

Here we just note, that the winning numbers were: 12, 2, 4, 20. Since no equilibrium here was theoretically found, we can only gather data at this stage and formulate hypothesis to found one.

All experimental data and R file for graphs can be accessed in open repository (Ignatenko, 2021).

4 CONCLUSIONS

In this paper we have presented approach to make experimental game theory work for learning in educational process and be a research tool at the same time. Our result show classical pattern in decision making – actually every group behave in almost the same way dealing with unknown game. Some tried to deviate for unusual actions (like choosing 100 or choosing 69), and this is interesting point of difference with more "laboratory" setup of existing research. The main findings of the paper are following:

1. To learn the rules you need to break them. Participants have chosen obviously not winning moves (> 66) partly because of new situation and trouble with understanding the rules. But high percent of such choices was present in second round also, when players knew exactly what is going on. This effect was especially notable in the cases of high school and adults and almost zero in case of special math schools and kids below 9th grade. We can formulate hypothesis that high school is the

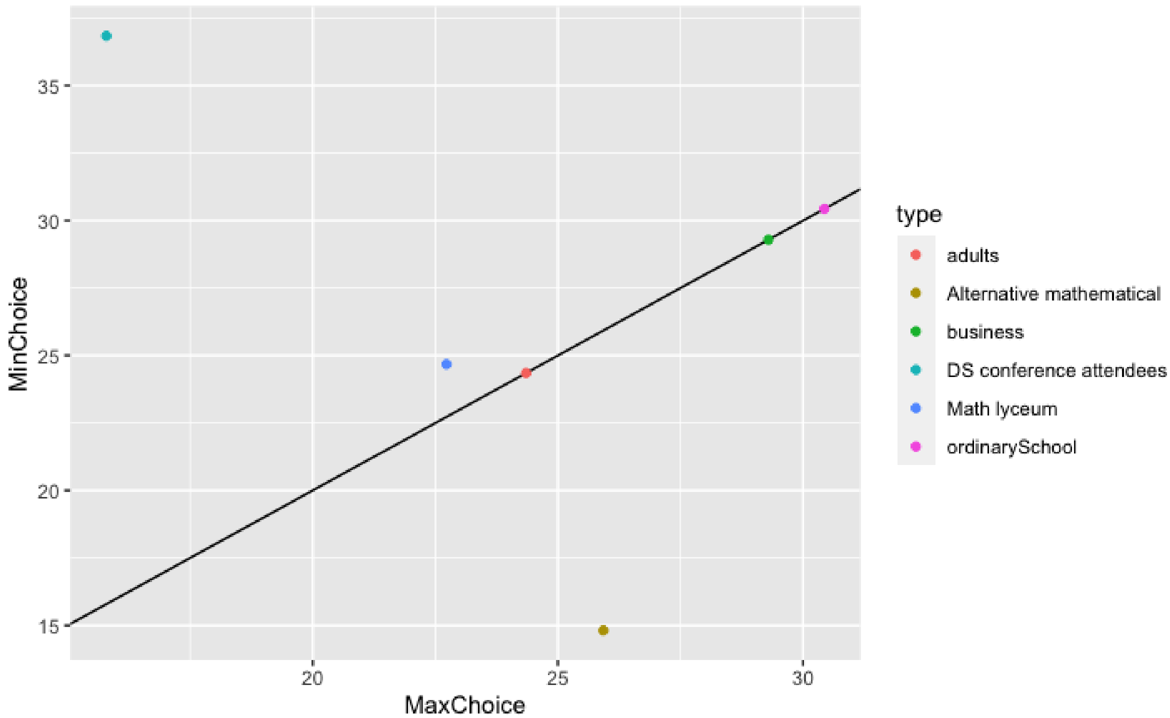

Figure 7: Difference in percent of rationalizable choices.

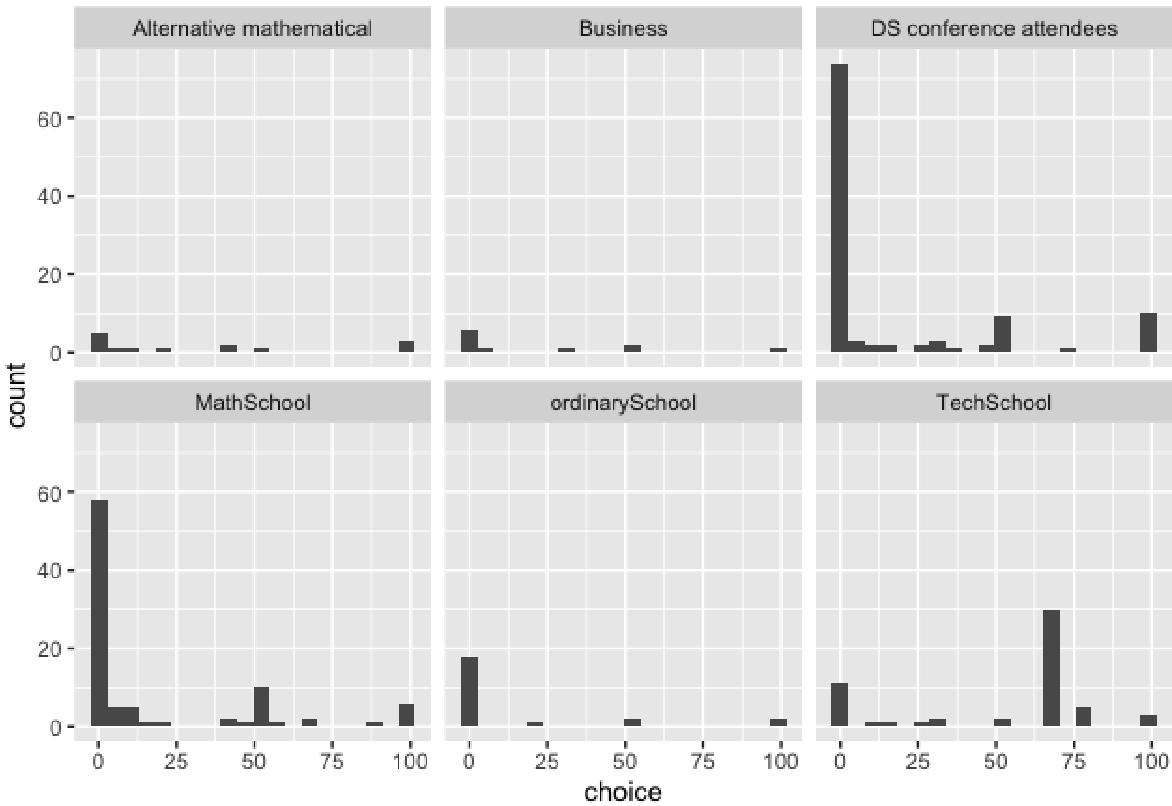

Figure 8: Histogram of choices.

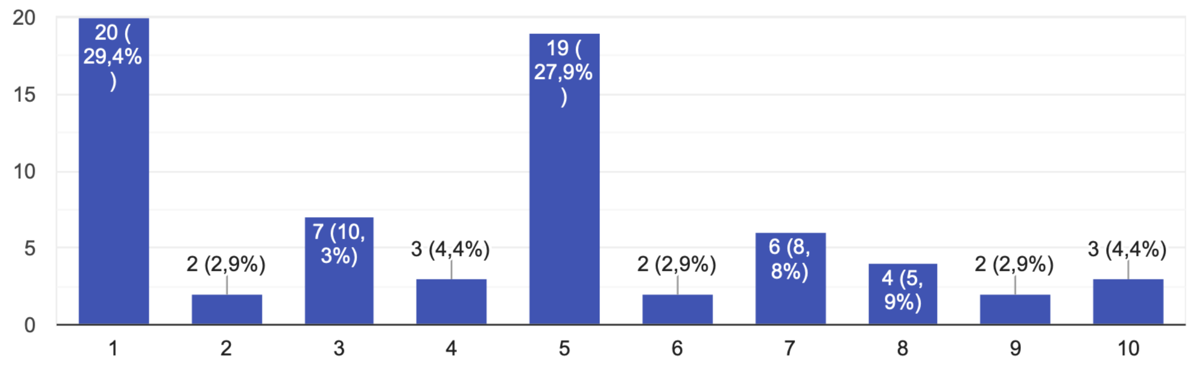

Figure 9: Histogram of choices for 1-10 game.

age of experimentation when children discover new things and do not afraid to do so.

2. If we considered winning number as decision of a group we can see that group learning fast and steady. Even if some outliers choose 100, mean still declines with every round. It seems that there is unspoken competition between players that leads to improvement in aggregated decision even if no prize is on stake. Actually, it is plausible scenario when all participants choose higher numbers. But this didn't happen in any experiment. The closest case – Tech school, when bunch of pupils (posible coordinating) switch to 100 still only managed to keep mean on the same level.
3. In second game the surprising result is that players use mixed strategies very well. It is known (from experiments of Colin Camerer) that chimpanzee can find mixed equilibrium faster and better than humans. It seems that concept of mixed strategies is very intuitive and natural. But still in quite unfamiliar game players made almost equal number of 1 and 100, so each player unconsciously randomized his own choice.
4. In third game players coordinates to 1, as expected, because of condition that from numbers with equal choices – lesser wins. Also we can note attempts of coordination around 7, 50 and 100. What is interesting is that in practice the condition was never applied – majority chooses 1 and that's it. If we decrease the numbers range to 1-10, other numbers has chance to win (5 or 7 for example). So this is unexpected result – increasing of number of choices leads to bigger uncertainty when players trying to find slightest hint what to do, and this is condition of "lesser wins". When players apply this condition to big area, they probably think – "1 is perfect choice, and other will think in that way also, this increase chances of winning".

The results have multiple applications:

- to provide kids with first hand experience about strategic interactions and explain their decisions;
- to demonstrate how game theory experiments can be used in educational process;
- to understand difference in decision making among groups;
- to compare results with classical experiments and replicate them in current Ukrainian education system.

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The Implementation of Inquiry-based Learning in the Organization of Students' Research Activities on Mathematics

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Keywords: Inquiry-Based Learning, Research Activities on Mathematics, Emotional State.

Abstract: The article looks into the issue of developing an interest of students' research activities on Mathematics. The study is dedicated to the feasibility of involving the inquiry-based learning to the organization of students' scientific research during the practice on the Approximation Theory and Fourier Series. The research considers the results of the survey among students who helped to evaluate their emotional state during the workshop. To collect the data we used the tool of express evaluation of positive and negative emotionality the Differential Emotion Scale by Izard. The article discusses the positive influence of the environment developed through the inquiry-based learning on students' emotional state and forming their interest in scientific research while organizing practic classes. We have grounds to conclude that there is the efficiency of implementing workshops based on the inquiry-based learning. The index reduction of students' negative emotions encouraged their activity during the practice and the improvement of interest in research activities.

1 INTRODUCTION

One of the main objectives of higher education is to form scientific competencies among would-be specialists that are necessary for further successful professional or academic development. Nechypurenko and Soloviev (Nechypurenko and Soloviev, 2018), Yarullin et al. (Yarullin et al., 2015) have called the organization of students' research activities one of the mechanisms to form their research competence. During such activities, skills that allow a graduate student to create new actual methods of professional activity in the future, develop new ideas and approaches that correspond to the changing modern requirements, are formed. In particular, this idea is supported in pedagogical literature dedicated to mathematical education where the organization of research activities on Mathematics is considered to have a positive influence on the further graduate student's activities in professional researches (Jahnke et al., 1983; Turner, 2010; Vintere and Zeidma, 2016; Proulx, 2015; Koichu and Pinto, 2018). Taking it into ac-

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count, the matter of organizing research activities on Mathematics is still actual in pedagogical researches.

Traditional learning methods focused on the teacher do not provide active students' involvement in research activities (Yore, 2001). According to the results of the researches conducted by the European Association for Quality Assurance in Higher Education, the European University Association, and the Higher School Teachers European Society (EURASHE, 2015), the success of forming students' research activities depends on the selection of learning strategy that is determined as a priority of its methods, where methods of student-focused education come first. It is connected with the variety and increasing expectations from higher education that in its turn requires fundamental changes in providing it and is focused on flexible learning ways of students' involvement in research activities. One of the methods of realizing such an approach is inquiry-based learning that has an official status in many countries of the world (National Research Council, 2000; Rocard et al., 2007; National Research Council, 2006). inquiry-based learning is included in the student-focused educational paradigm where students have to build their activities in the same way as scientists during the process of learning and knowledge grounding. In Mathematics this is emphasized in works (Sandoval and Reiser, 2004; Jahnke et al., 1983; Artigue and Blomhøj, 2013; Dorier and Maass, 2020), where it is stated that Inquiry is one of the most important contexts while learning mathematics. So, the matter of organizing research activities in Mathematics through the implementation of inquiry-based learning corresponds to the requirements of the most important issues of modern fundamental education.

Many authors have emphasized the necessity to support active students' research activities. Lithner (Lithner, 2000) pointed out that international tendency in Mathematics education is acquiring mathematical knowledge not only in terms of context but in terms of getting skills connected with carrying out mathematical research. Bonwell and Eison (Bonwell and Eison, 1991), quoted in (Fallon et al., 2013), stated that students have to do more than just listen. They have to read, discuss, and do research on the problems. Jones et al. (Jones et al., 2019) confirm that at every level of university students' training it is necessary to form their creative thinking and their investigative skills. Scientists emphasize that the organization of students' research activities during their training encourages the development of research competence, necessary both for solving practical problems and for being able to adapt fast to the changeable conditions of the modern time and master their skills constantly. We also took into account the ideas of Dreyfus et al. (Dreyfus et al., 2018), who considers research activities during Mathematics learning as a natural part of the educational process, which is directed at forming research competence among students.

According to Yore (Yore, 2001), the formation of interest in research activities is the first stage during the development of research competencies while learning Mathematics. This idea is agreed with the conclusions by Hernandez-Martinez and Vos (Hernandez-Martinez and Vos, 2018), who have described the critical state of the matter to form students' interest in research activities. Scientists emphasized the importance of organizing students' activities, the formation of their positive attitude to research projects. While learning the literature, the authors of this research were especially interested in the work (Mathiassen, 2000) that describes a research project that included a group of researchers and practitioners who have worked for three years to understand, support, and improve the methods of Systems Development. The work proved a positive influence of practice on theoretically strict research processes and suggested the means of developing research projects that are based on combining traditional theoretical research with experiments and practice. However, not every practical class can be considered a research stimulus. In the organization of research activities, the key aspects of inquiry-based learning are the ability of students to develop new ideas based on previous knowledge and scientific facts; restructure their previous ideas about the scientific concept by adding new studied information; take into account each other, monitor and evaluate their own learning. Only due to this, it is possible to transfer new knowledge into a real context.

In order to organize practice-focused research activities scientists offer to use special courses dedicated to special scientific researches in the priority areas of modern Mathematics. This fact is evidenced by the opinion of Yarullin et al. (Yarullin et al., 2015), Biza et al. (Biza et al., 2016), Telegina et al. (Telegina et al., 2019) about the significant potential in the researches on forming a positive attitude to students' research activities using the materials of different mathematical branches. In scientists' opinion, the use of interesting mathematical theories encourages students to get a more meaningful education of theoretical materials, facts, and methods of solving mathematical problems and it allows getting particular experience. We can also meet the confirmation of this opinion in the works by Matejko and Ansari (Matejko and Ansari, 2018), Sevinc and Lesh (Sevinc and Lesh, 2018), who investigated the organization of research activities related to particular branches of Mathematics.

The idea caught on, that is why guided by the conclusions made by the above-mentioned scientific researches we decided to research the formation of students' interest in research activities on Mathematics through the implementation of practice on approximation theory following inquiry-based learning. The choice of this branch results from its extensive use in practice. This is explained by the fact that the modern stage of science and technology development is characterized by the use of a considerable amount of information. As experience shows this tendency will only enhance in the future – the development of computer science, telecommunication, and registration equipment lead to steady growth of the data amount. Therefore, the tools and methods of their processing and analysis are growing. The creation of a single methodical approach based on general mathematical principles is actual for several tasks such as to get, model, register, and process data. The series finds a mass use as a tool to represent a considerable class of functions, carrying out analytical transformations, approximate calculations in many applied tasks. Algorithmic and computer software that is created on their basis is characterized by high universality and is included in computer and hardware-computer complexes of different purposes, which is confirmed by the numerous researches conducted by (Malvar, 1992; Pankratov et al., 2009), etc.

The research is aimed at forming students' interest in research activities on mathematics through the implementation of practice on approximation theory following inquiry-based learning.

2 METHOD

At the first stage of the research, we used a survey method to assess students' interest in Mathematics research activities. We used the Differential Emotions Scale by Izard (Izard, 1977) to survey students. The relevance of involving this methodology to assess students' interest in research activities is proven by the researches where the direct dependency between the subject's interest in cognitive activities and their emotional state during its implementation is emphasized. Since the feeling is a dynamic component of the emotion (Panksepp, 2003) and two psychobiological processes are connected with it – fascination and individuation (Langer, 1967), motivating, managing, and informative functions of feelings allow them to capture or simplify and organize the thing that can become (especially in difficult situations) a great number of impulses in concentrated cognitive processes. During 2015–2019 we surveyed master's degree students of Physics-Mathematics departments of Kryvyi Rih State Pedagogical University and Berdyansk State Pedagogical University. 49 master's students took part in the survey (17 male students and 32 female students aged from 20 to 28). The use of the online survey, first through Google form, posted on the Internet, and then, moved to the forum of the platform "Higher School Mathematics Teacher" (Vlasenko and Sitak, 2019) had an advantage in comparison to the survey on paper as it encouraged the respondents' frankness and prevented missed questions.

According to the chosen methodology, we selected the Likert scale to assess each of the basic emotions where 1 – "feeling is completely absent"; 2 – "feeling is slightly expressed"; 3 – "feeling is moderately expressed"; 4 – "feeling is strongly expressed"; 5 – "feeling is fully expressed". At the beginning of the research, the most significant (> 9 points) positive emotion related to the experience of Mathematics research activities was "interest", negative – "shame" and "fear". Students usually face the last two emotions while learning Mathematics.

Students believe that the key problem of learning mathematical theory is the absence of the connection between theory and practice and the abstract character of the subject.

At the second stage of the research, we determined the structure of practice regarding Approximation theory and the main aspects of the content that ensure its correspondence to inquiry-based learning. While selecting resources for the analysis of possibilities to use inquiry-based learning we were focused on those that represent the efficiency of its use during the education. Among them, we can name TeachThought (Lesley University Online, 2017), Lesley University (Lesley University Online, 2019), The National Academies Board on Science Education (Bybee, 2009), Alberta Education (Alberta Learning, 2004) (table 1).

We also found out what the purpose of using inquiry-based learning by other scientists was. Cheng et al. (Cheng et al., 2016) noted the efficiency of using the approach to increase the motivation of students' learning. Duran and Duran (Duran and Duran, 2004) describe the use of inquiry-based learning in programs of professional development in education. Supasorn and Promarak (Supasorn and Promarak, 2015) see the use of inquiry-based learning as an efficient method of improving students' understanding of natural processes.

In conclusions of scientific researches (Bybee

Table 1: The analysis of the resources that represent the efficiency of using inquiry-based learning.

Resources	**Used while learning a subject**	**Features**	**What are the efficiency grounds**
Teach Though	Biochemistry and Molecular Biology Education, Mathematics	Joint activities	The solid knowledge foundation through an active part
Lesley University	Mathematics, Life sciences	Constructing knowledge based on experience	Possibility for the full cycle of education
The National Academies Board on Science Education	Biological sciences	Structure and sequence of education are directed at creating a challenging situation	Integration of learning activity with laboratory experience
Alberta Education	Librarianship, work with information	Student's involvement in metacognition; encouragement of critical and creative thinking	Focus on achieving defined learning outcomes in different subjects

et al., 2006; Abdi, 2014; Ong et al., 2018) we also find the confirmation of the efficiency to use the above-mentioned approach to improve students' achievements in science. Considering it, we believe that inquiry-based learning will encourage the alignment of teaching processes with the formation of better students' understanding of scientific knowledge and skills during practice.

The practice program consists of six classes.

1. The history of the development of approximation theory and Fourier series.
2. The ways of periodic function classification.
3. Approximation methods that are based on matrix series summing.
4. Main tasks of approximation theory: approximation of individual function, class approximation, precise, and asymptomatically precise ratio.
5. Examples of researches by subject.
6. Examples of using approximate aggregates in computer complexes of broad purpose.

The practice was aimed at the formation of students' interest in research activities through their implementation in the real process of using series in applied tasks.

The practice was held for a group of 7–8 students twice a month for three months. Every class included two hours of classwork and three hours of extracurricular work. The classes were held by the prominent teachers of Mathematics departments who took part in the development of the practice and looked for the method, the implementation of which would encourage the formation of students' interest in research activities during the practice.

During the organization of practice classes, we developed recommendations for every practice stage that have to encourage the increase in students' interest in mathematics research activities.

At the first stage, the teacher has to determine what students already know regarding the concept that is considered and what kind of knowledge they still need. In order to master new educational material, it is necessary to help students to revise Mathematics sections such as Algebra, Mathematical Analysis, Functional Analysis, and Function Theory. Moreover, at this stage, the teacher is only a consultant who helps students to prepare short reports encouraging students' interest and motivation. For this purpose, the teacher presents the actuality of the researches dedicated to learning approximate features of approximation methods that are generated by certain transformations of partial sums of Fourier series and allow building the sequence of trigonometric polynomials that would equally coincide for any function (table 2).

Table 2: Recommendation for the teacher on the organization of the first stage.

Appropriate	**Inappropriate**
encourage students to raise their questions offer to compare their ideas with others	read the lecture give definitions to terms explain or give tasks

The second stage is aimed at strengthening students' activities regarding knowledge and skills. At this stage, students can revise the tasks that use the methods of Approximation theory on special subjects that they learn. As a rule, students cite examples of tasks on periodic signal approximation in the theory of control engineering, pattern recognition, non-destructive testing, etc. Students can discuss and write down approximation methods in every particular case. The teacher is only a consultant who offers students such research methods as observation, hypothesis generation, forecasting. Students' communication and work in groups without the direct teacher's involvement are encouraged to equally coincide for any function (table 3).

Table 3: Recommendation for the teacher on the organization of the second stage.

Appropriate	Inappropriate
encouragement of search for several ways to solve the problems comparison of ideas self and mutual survey	use of traditional explanation implementation and involvement of a great amount of terminology

At the next stage, students can describe their point of view regarding the search for solving extreme problems of approximation theory. After this, the teacher has to introduce common terminology and acquaint the students with the general scheme of researching integral images of trigonometric polynomial variations that are generated by linear methods of summing Fourier series, from periodic functions. Generating students' new ideas on methods of approximation improvement, their comparison with the ideas of the previous stage is possible. At this stage, the teacher also has to prevent possible mistakes while explaining misconceptions that could arise at the stage of engagement and exploration. During the classes of this stage, the teacher involves interactive methods and presentations for mathematical modeling of periodic processes (table 4).

After getting an explanation about the research main scheme regarding integrated images of trigonometric polynomial variations during the classes of periodic functions it is important to involve students in further research activities. Further work includes significant analytical calculations connected with exact and approximate methods. Starting from the integral image students can learn asymptotic behavior of exact upper bounds of deviations of trigonometric polynomials from periodic functions to infinity. The stage is aimed at helping students to develop a deeper understanding of general methods of mathematical analysis and the use of approximation processes in practical

Table 4: Recommendation for the teacher on the organization of the third stage.

Appropriate	Inappropriate
teacher's explanation expression of the ideas using generally accepted terms idea review and formation of new ones	forming a great amount of terminology focus on independent work

tasks. Students can carry out additional researches, develop new approximation methods, exchange ideas, and use acquired research experience to integrate Approximation theory in practice (table 5).

Table 5: Recommendation for the teacher on the organization of the fourth stage.

Appropriate	Inappropriate
enhancement of understanding through strengthening the ideas acquired by experience use of algorithms that are close to new situations grounds for conclusions support of forming student's proper ideas	development of the ideas that are not connected with previous experience generating a great number of ideas without deepening in the essence of the theory

The practice of working in small groups is important at this stage. The lessons include planning and preparation of students' proper development on using the considered approximation methods from every group of students. It is possible to create an algorithmic and program-algorithmic product based on the created methods. As the simplest and at the same time the most natural example of a linear process of approximation of continuous periodic functions of the real variable can be the approximation of these functions using the sequence elements of partial sums of Fourier series, the greater majority of students have a basic idea about the techniques of using these methods while creating an algorithmic product. But, as it is well known, the sequences of partial sums of Fourier series $S_n(f;x)$ are not equally similar for the entire class of continuous periodic functions. Thus, a considerable number of students' developments in this area are directly dedicated to the learning of approximate features of other approximation methods that are generated by particular transformations of partial sums of its Fourier series for this function and allow building the sequence of trigonometric polynomials that would be completely similar for every function (Rovenska, 2019). Fejer sums $\sigma_n(f;x)$ are arithmetic averages for the first n of partial Fourier sums for this function and, as it is known, the sequence of polynomials $\sigma_n(f;x)$ equally coincides with its function. Sums of de la Vallee Poussin $V_{n,p}(f;x)$ are a synthesis of sums $\sigma_n(f;x)$ and have approximate features that depend a lot on the parameter p. Trigonometric polynomials $V_{n,p_1,p_2}(f;x)$ that are generated by the repeated use of de la Vallee Poussin summation method are the further synthesis of classical Fourier methods, de la Vallee Poussin and Fejer (Novikov and Rovenska, 2017). Choosing particular parameters p_1 and

p_2 these polynomials coincide with the sums $S_n(f;x)$, $V_{n,p}(f;x)$, $\sigma_n(f;x)$. The works of practice participants should be dedicated to the learning of approximate features of such approximation methods showing graphically the advantages of its use (figure 1, 2). For the visualization, students can be recommended a system of computer mathematics Maple that includes developed graphic means.

The demonstration of the efficiency of the selected approximation methods can be done by comparing the results of numerical experiments held simultaneously for the operators $S_n(f;x)$, $V_{n,p}(f;x)$ and $V_{n,p_1,p_2}(f;x)$. Meanwhile, it is necessary to pay students' attention to the fact that the aggregate of all the harmonicas that are used to build the operators $S_n(f;x)$; $V_{n,p}(f;x)$ coincides with a similar aggregate for the operator $V_{n,p_1,p_2}(f;x)$. At the same time, the program for the numeric implementation of the values $S_n(f;x)$, $V_{n,p}(f;x)$ and $V_{n,p_1,p_2}(f;x)$ can be developed using Python. This tool is easy to use for students–non-programmers and is suitable for easy calculations.

The final stage of practice is dedicated to evaluation. Evaluation is considered to be a permanent process during which the teacher only observes the students and supports them during report presentations, idea introduction, and question tasks. The use of peer assessment is relevant. Such a form of evaluation can be complemented by students' self-assessment of their level. During the classes of this stage, the teacher involves interactive methods and presentations for mathematical modeling of periodic processes (table 6).

Table 6: Recommendation for the organization of the final stage.

Appropriate	Inappropriate
evaluate the progress in general in comparison to the initial level evaluate the ability to use approximate methods to solve complex problems give students feedback regarding the feasibility of their ideas encourage questions that enhance a deeper understanding of the influence of individual function features on the approximation order	evaluate single facts and separate elements of approximation theory offer a survey in a test form

The use of inquiry-based learning does not oblige the teacher to strictly follow the indicated stages. If necessary, it is possible to repeat them several times (Bybee and Landes, 1990). This fact proves the flexibility of using this approach for the implementation of scientific practice.

3 RESULTS

During the preparation stage, we selected the target type as a selection strategy, because the selection had to include the students who have a high achievement level in mathematical branches. By high level, we understand the absence of the final mark "satisfactory" and lower following the national 4–level scale "unsatisfactory", "satisfactory", "good", "excellent" for each of the subjects "Algebra", "Mathematical analysis", "Functional analysis" and "Function theory". The target selected analysis provided us with a sample size n=49 of students that represents 23% of the general number of master's degree students of the first year during 2015–2019. At the stage of organizing data collection, we used the tool of express-evaluation of positive and negative emotional states called the Differential Emotion Scale (Izard, 1977), which ensures diagnostics of a wide range of emotional states. Each of the ten basic emotions (x_i, $i = 1,2,...,10$) is represented by three independent changeable 5–character scales for factors that describe emotional states. The points on every scale correspond to the level of emotional feedback and can be in total from 3 to 15 points. The stage of data analysis of every profile implies the selection of significant (> 9 points) emotions, creation of "emotion profile", determination of the dominant emotional state.

At the beginning of the research, the most significant positive emotions regarding the experience of research activities are "interest", negative – "shame" and "fear" (table 7).

While processing every profile we defined the indexes of emotional states that characterize the level of subjective students' emotional attitude to the present experience of research activities. The Index of positive emotions and Index of critically negative emotions could range from 9 to 45 points, the Index of anxious–depressive emotions ranged from 12 to 60 points. We defined that the positive emotional state turned out to be dominant among 69.4% of students; a strong level (> 36 points) of expressing a positive emotional state was marked only among 6.1% of respondents. Also, a distinct (from 29 to 36 points) level of positive emotional state was fixed among 10.2% of students. Other students (53.1%) showed moderate (from 20 to 28 points) and weak (< 20 points) level. So, most students' attitude to the research process can be mainly characterized as positive. However, this positive attitude is weakly expressed, unstable, and cannot ensure the proper motivation in overcoming difficulties that inevitably arise during research activities. This fact plays an important (if not the most important) role in the failure of attempts to involve an

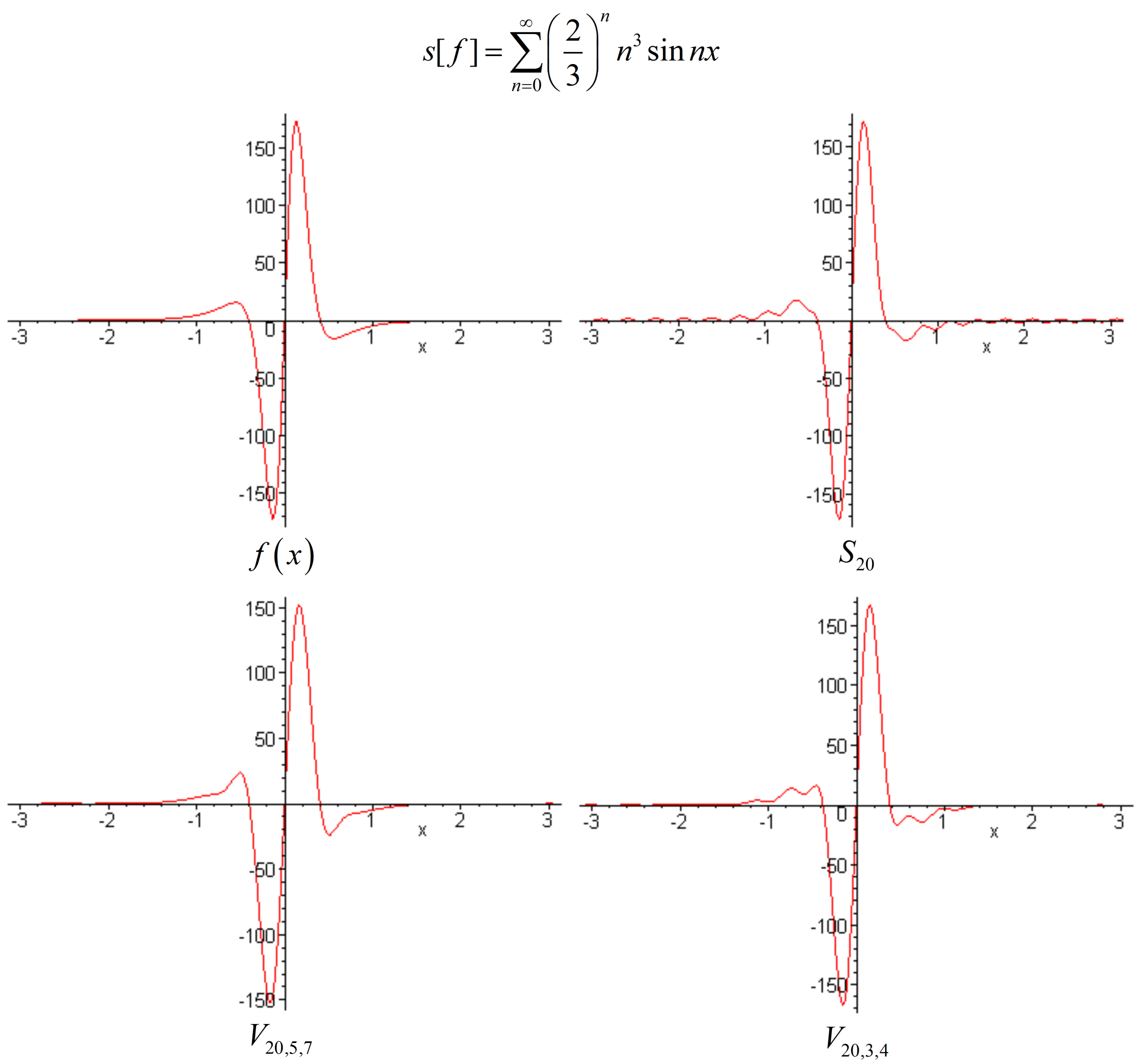

Figure 1: Visualization of functions and trigonometric sums that are generated in different methods of summarizing Fourier series in the system of computer mathematics Maple.

Table 7: Distribution of significant emotions at the beginning of the research.

Emotion	**Number of students who have this emotion as dominant (>9 points)**	**Comparison with the general number of students**
Interest	32	65.3%
Fear	45	91.8%
Shame	27	55.1%

unprepared student in research activities in any area, including Mathematics.

The dominant critically negative emotional state regarding the present experience of research activities was fixed among 12.2% of respondents, half of whom had a strong (> 32 points) or distinct (from 25 to 32 points) level. It is important that among all the students who had the critically negative state as dominant, the factor "Dull" took no less than 4 points, and, accordingly, made the greatest contribution to the calculation. It testifies a stereotype regarding the complexity and absence of interest in research activities among young people. We considered this aspect while searching for methods of practice implementation.

As mentioned above, the emotions "fear" and "shame" were detected as significant among 91.8% and 55.1% of respondents. These emotions are in-

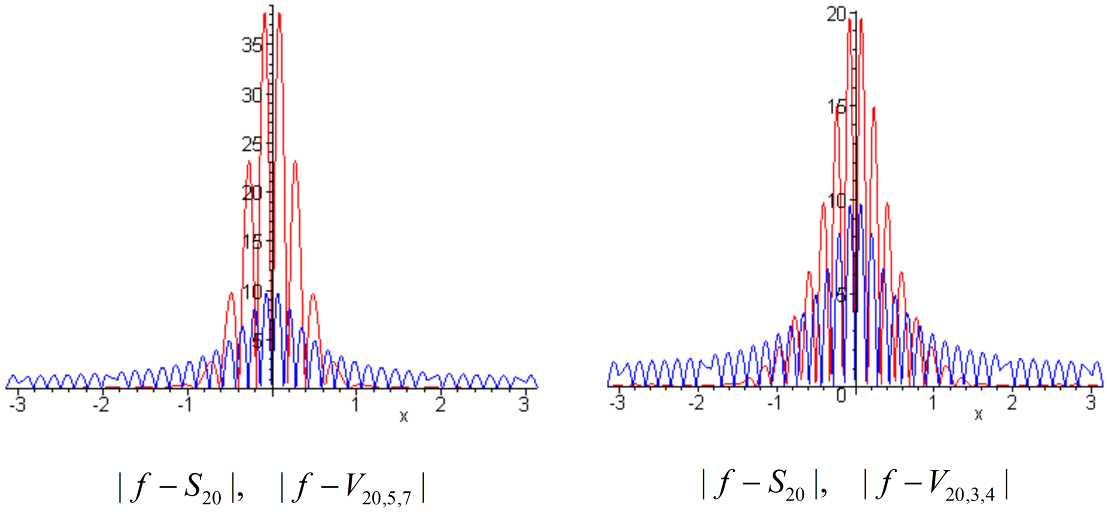

Figure 2: Visualization of deviation of Fourier series and repeated de la Vallee Poussin repeated series from the function $f(x)$ in the system of computer mathematics Maple.

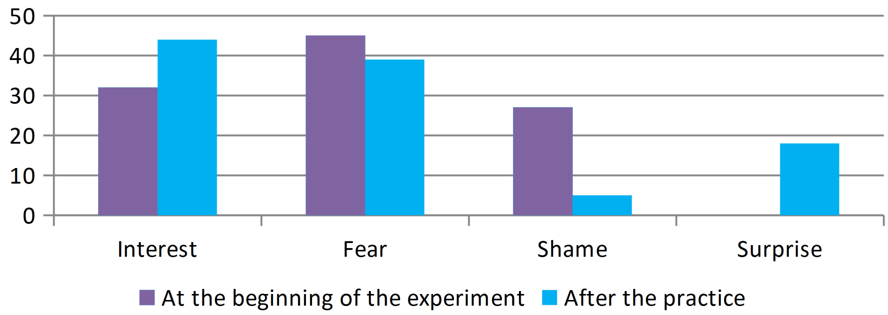

Figure 3: Distribution of a significant emotion.

Table 8: Distribution of significant emotions after taking practice.

Emotion	**Number of students who have this emotion as dominant ($>$ 9 points)**	**Comparison with the general number of students**
Interest	44	89.7%
Surprise	18	36.7%
Fear	39	79.5%
Shame	5	10.2%

cluded in the third group of emotions that determine the anxious–negative emotional state of the subject regarding the experience of research activities. Despite this fact, the given state is dominant only among 18.4% of students. It demonstrates that these two emotions influence the formation. 4.1% of respondents have strong ($>$ 30 points) level of emotional state, distinct (from 21 to 30 points) – 10.2%, moderate (from 12 to 20 points) and 4.1% of respondents – weak ($<$ 12 points). Such a noticeable selection of two emotions in the general image of the emotional state confirms the idea that fear and shame prevent students from implementing their interest in the research process and take an active position while conducting research.

The repetitive survey was carried out after finishing the practice. The distribution of significant emotions after taking practice is represented (table 8).

Interest turned out to be a significant positive emotion among 44 students. We can note that the number decrease in students who had shame as a significant negative emotion is well seen – 17 respondents. At the same time, the number decrease of students who had fear as a significant emotion is minor – 6 students (figure 3).

Despite this fact it is impossible to claim that this emotion in the context of the given research is badly adapted. The profile analysis of respondents' emotions shows the decrease of fear expression to varying degrees among 77.5% of students. The presence of surprise among the significant emotions, as well as interest, which is included in the positive group, is predictable.

More detailed analysis of the feasibility of implementing practice that was carried out using the index calculations of students' emotional states. We detected the increase of students with the dominant positive emotional state up to 81.7%, where 63.2% of respondents had a strong and distinct level. At the beginning of the practice, the same indicator was 16.3%. Thus, we managed to form a stable positive attitude to research activities among more than half of the practice participants.

The number of students who have a critically negative emotional state as dominant remained at the level of 12.2%, though the qualitative structure of this subgroup changed. In our opinion, it is connected with a greater amount of working practice in small groups during classes in comparison to individual work. As teachers pointed out certain students perceived such a format negatively.

The dominant anxious–negative subject's attitude to experience of research activities after taking a practice was fixed among 6.1% of students. Among them 4% of respondents have moderate and 2.1% – weakly expressed level of emotional state. The comparative analysis of the students' number regarding dominant emotional states is displayed (figure 4).

The analysis of the results proved that creating the environment based on inquiry-based learning during the scientific practice where students did not feel negative emotions to research activities encouraged the increase of their interest in research activities.

4 DISCUSSION

Searching for ways of forming students' interest in research activities on mathematics we faced the researches (Sandoval and Reiser, 2004; Rocard et al., 2007). The scientists point out that in order to form students' impression of the real world it is necessary to show them how to organize their activities as real scientists do during the process of learning and knowledge grounding. Fallon et al. (Fallon et al., 2013) offered to seek the possibilities to organize students' research activities through the method selection and forms of a learning organization that influences active students' involvement.

Traditional educational methods, which are focused on the teacher, don't provide an active students' involvement in research activities (Yore, 2001; Lin et al., 2014; Vlasenko et al., 2019). The scientists emphasize the importance of searching for educational models that encourage the strengthening of students' learning activities. The Deductive Content Analysis Method helped us to choose inquiry-based learning as the foundation of developing a scientific environment for students' education.

The efficiency of inquiry-based learning to encourage students' research activities is proved in (Duran and Duran, 2004; Bybee and Landes, 1990; Suparsorn and Promarak, 2015; Cheng et al., 2016). Also, we support the opinion by Vlasenko et al. (Vlasenko et al., 2019), who believe that learning has to be built so that students can research, explain, extend and estimate their progress, and the introduction of ideas assumes students' awareness of the reason or necessity of their use. The indicated aims are fully agreed with the content of inquiry-based learning.

Alshehri (Alshehri, 2016) believes that while organizing research activities it is necessary to direct students to the main models of subject matters. One of the key subject matters of Mathematics is Approximation theory, its broad influence on the modern state of innovation and technology development is widely known. The research is aimed at searching for ways of implementing a practice on Approximation theory to form students' interest in Mathematics research activities. The main research result testifies that the use of the approach inquiry-based learning influenced efficiently the formation of students' positive attitude towards research activities. Within this approach, the involvement of the practice on Approximation theory encouraged the increase of the level of expressing students' positive emotional state (particularly interest, surprise increase) and decrease of anxiety level. These results are agreed with the conclusions by Chin and Lin (Chin and Lin, 2013), Abdi (Abdi, 2014), Jung et al. (Jung et al., 2014), Ong et al. (Ong et al., 2018), who studied the connection between interest growth and a person's emotional state. This justifies the use of methodology Differential Emotions Scale by Izard (Izard, 1977) during the experiment.

5 CONCLUSION

The actuality of involving students in research activities in education arises from the fact that research competence is considered as one of the components of professional competence. Enhancing students' interest in research content and research activities during the studies also requires the use of an approach

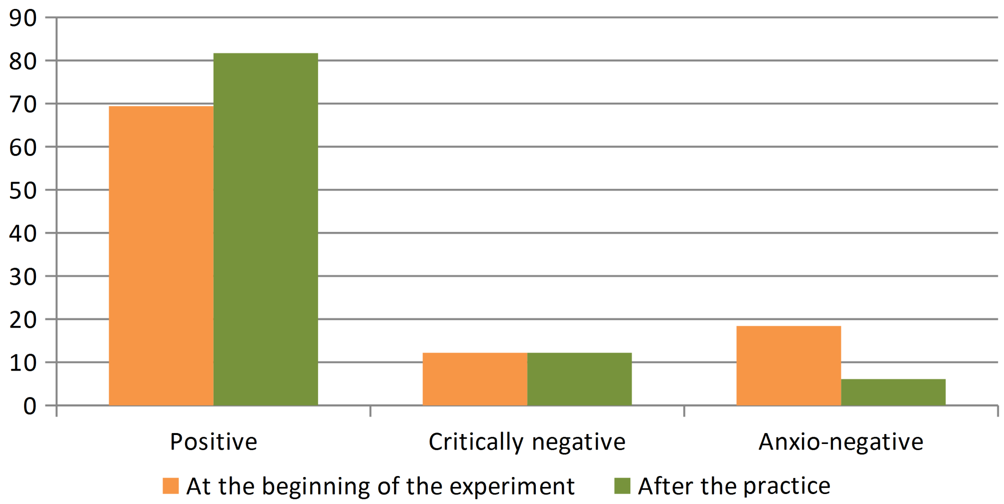

Figure 4: Distribution of dominant states.

that implies complete students' awareness of the importance of the research problem. The Deductive Approach to Content Analysis helped us determine the possibility to involve inquiry-based learning to the organization of practical classes on Approximation theory, determine its characteristics and efficiency parameters, predict that the approach can ensure the formation of a better understanding of scientific knowledge and students' skills. According to inquiry-based learning, we developed the content of the practice on Approximation theory. Based on the analysis of the current recommendations on using inquiry-based learning while studying different subjects we offered recommendations on the organization of practice. It should be noted that the course should be provided following the indicated recommendations that encourage students' activity, their interest in the research activity.

Forming a positive attitude to research activities is the first step to the development of the research competence of pre-service specialists. The analysis of the works on the connection between the person's interest and emotional state allowed formulating the most important positive and negative emotions that are connected with the experience of the research activities. The results of calculating the indexes of students' emotional states proved that the creation of the environment according to inquiry-based learning where students do not feel negative emotions to research activities encourages emotional state and interest in research activities.

The perspectives of future research involve the creation of Math courses that use inquiry-based approaches with the purpose of further research on forming research competence among students.

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The Formation of a Successful Personality of Primary School Children during Media Education Implementation (Using Praxeological Tales)

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Keywords: Successful Personality, Primary School Age Pupil, Technology, Media Literacy, Praxeological Tales, Media Education.

Abstract: The article substantiates the relevance of implementing the technology of formation of a successful personality of a primary school age pupil during media education implementation using praxeological tales at primary school. A technology model is developed. The necessity of solving problems of success simultaneously with increasing the level of media culture of a pupil, the formation of key competencies for life, preparation of a child for the life's self-realization on the basis of the partnership implementation of schoolchildren, parents and teachers is proved. The necessity of the embodiment of the pedagogy of heart and the pedagogy of success by spreading the idea about the connection between success and sensitivity, humanity, providing support to those who need it is shown. The results of the latest research on the role of moral values, cooperation in human evolution, the prosperity of society, are reflected. The need for these results discussion with parents and pupils is shown. The diagnostic toolkit for determining the levels of formation of the successful personality of primary school pupils is specified. The effective forms and methods of the schoolchildren education are substantiated: the creation of electronic books, projects "Rules of Success Achievement", "Stories of Success", "Sensitivity and cruelty: which wins?", "Rivalry or cooperation: my choice?", watching movies about successful people with special needs, analysis of media products on the topic of success. The ways of educating parents about the problems of children's success are determined. The results of experimental research are analyzed. The necessity of studying the rules of achieving success on the basis of reading and comprehensive analysis of praxeological tales, improving the content of textbooks in the context of achieving success, increasing interest to children's periodicals is revealed. The formation of a successful pupil is considered as one of the ways to strengthen the Ukrainian state. The necessity of raising the authority of the teaching profession is proved.

1 INTRODUCTION

1.1 The Problem Setting

In the last decade in the pedagogy of primary education, the problem of success and successfulness has become rather actual. There exist a few reasons for the interest in these issues. Usually, success is associated with financial independence or wealth. It is known that in Ukraine is not one of the countries with a high level of economic development. One of the ways to overcome poverty lies in developing children's successful personality features. Such education should begin at primary school. The success of a primary schoolchild serves as a start for achievements in high school and a basis for life-long self-realization in the future. In addition, the interest in the success development is due to the introduction of the Concept of a New Ukrainian School (Elkin et al., 2017), the New State Standard of Primary Education (MON,

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2017), which focus school teachers of the first degree to develop students' initiative and entrepreneurship as key competencies, skills to think critically and creatively, solve problems, organize own activities, which are through skills. The implementation of media education is another important problem of the primary school, the relevance of which in the educational sphere is reflected in the Concept of Media Education Implementation in Ukraine (ms.detector.media, 2016), Typical educational programs. The formation of a successful pupil by means of the Concept enables to solve tasks on the way to success through the development of media culture, information and digital competence. The analysis of scientific sources proves that media is a powerful instrument of influencing personality, but their role in educating a successful pupil is underestimated, especially in the primary school. The imperfection or lack of patterns for imitation in the Ukrainian media, in particular, literary texts, incorrectly placed emphases on values that allow to achieve the goal can be one of the weighty reasons for the acute need of the society in the intellectual elite, effective managers, who would lead Ukraine to the central positions among the states with a high index of human development.

1.2 Literature Review

Scientific researches of the problems of forming a successful personality are carried out in several planes: the formation of a successful personality in primary school; the factors to achieve success; the role of the media in forming a successful personality. The significance of childhood success for life self-realization, ways of preventing a loser complex are highlighted by Glasser (Glasser, 1973), who wrote in particular: "It is here [in the primary school classroom] that the child most often forms the lifelong concept of himself as a successful or a failing person. That's why the impact of school failure is so devastating: it attacks and destroys the child's initial identity as a successful person" (Glasser, 1973, p. 39).

Wagner and Ruch (Wagner and Ruch, 2015) have shown the interconnection between character strengths (such as perseverance, self-regulation, prudence, love of learning, hope, gratitude, perspective, teamwork, and social intelligence), positive classroom behavior, school achievements, because "being the nice student" will make the grade in just any subject. "It seems rather that character strengths facilitate achievement-related behavior that then may lead to better school achievements" (Wagner and Ruch, 2015).

Based on the results of this research we can affirm that character strengths directly influence on the achieving success in school. But these qualities should be formed and developed.

Important to our research are the ideas of MacBeath (MacBeath, 2012) on the necessity of gaining experience by a pupil to overcome difficulties as a factor of achieving success in the future. In this context, MacBeath (MacBeath, 2012) states: "The experience to deal with failure is a hugely telling indicator of school success and success in later life, the seeds of which are planted early. That every failure is a learning opportunity has gained the status of a cliché, but can only become a classroom reality when failure no longer carries high stakes penalties" (MacBeath, 2012, p. 61).

A thorough analysis of the problem of the six-year-old children's success was conducted by Maksymova (Maksymova, 2013). The scientist substantiated the pedagogical conditions for the achievement of success by pupils in the first grade in their productive activities in the process of subject-subject interaction and identified the diagnostic tools for the development of success.

On the basis of literature analysis, our own research, we have interpreted the concept of "successful personality of the primary school age pupil". It is a pupil whose activity results correspond to the specified goals; which he/she and his/her surrounding consider successful, based on modern social norms, customs, values and standards.

Given the relevance of media education, the researchers investigate the role of the media in forming a successful personality. The reflection of stereotypes about human success in media is shown in (Carr et al., 2008; Grzeszczyk, 2003; Kolber, 2016). Kolber (Kolber, 2016) hereby argues that comparing himself with the ideal created in the media leads to negative consequences (the appearance of low self-esteem, such a person does not feel happy) (Kolber, 2016, p. 79-80). The positive role of the media in forming a successful pupil is reflected in (Alishev and Gilmutdinov, 2010; Grynyuk, 2011; Krystopchuk and Yakymchuk, 2018), and others, who, studying the factors of success of schoolchildren in Finland and Singapore, found that the positive ideas of the experience of these countries is the dissemination in the media of the stories of success in the diligent and disciplined study and work environment, systematic reading of books, periodicals (Alishev and Gilmutdinov, 2010, p. 245), (Grynyuk, 2011, p. 2).

As the resource base analysis shows, the works of Grant (Grant, 1972), Hill (Hill, 1928), Kukk (Kukk, 2017), etc. are insufficiently popularized in the Ukrainian media. These authors proved that humanity, compassion, help to those who need it, allow you to become successful faster than sharp elbows, cruelty and cunning. In the primary school age, children are fond of fairy tales, compose these stories by themselves. But there is a lack of fairy tales, in which the rules of achieving success are determined. Tales in which such rules are reflected are interpreted as praxeological.

1.3 Research Question

As the resource base analysis shows, the problem of forming a successful personality of a primary school pupil during media education implementation, in particular by means of fairy tales, in the Ukrainian primary school was not the subject of a separate study.

The *purpose* of the article is to substantiate the technology of forming a successful personality of a primary school age pupil during media education implementation using praxeological tales.

1.4 Research Methods

A number of research methods have been used for the achievement of the goal:

- theoretical – functional and structural, interpretive and analytical, contrastive and comparative analysis of literary and informational sources, textbooks for pupils of the first-degree school, through which the researched problem was studied, forms, methods and means of formation of successful pupils were revealed; modeling (for the development of a model of technology for the formation of a successful personality of a primary school age pupil during media education implementation using praxeological tales);
- empirical – observation, questionnaire, survey, confirmatory and forming experiment (children of the second and third grades of comprehensive schools No 16 of Ternopil, No 30 of Khmelnytskyi, Mukachevo Educational Complex “Preschool educational institution – secondary school of the I degree – gymnasium”, Ternopil Educational Complex No 35, Kherson Educational Complex No 7 were involved in the experiment) to check the effectiveness of the technology of forming a successful personality of primary school age children during media education implementation using praxeological tales.

2 RESULTS

2.1 Media Education Tools for the Formation of a Successful Personality of Primary School Age Pupils

In primary school, due to the relevance of media education, children now know what media is and which media are. Traditional media used by the pupils of the first-degree schools include visual (fiction, textbooks, newspapers, magazines, pictures, photographs), audio (radio), audiovisual (theater, television programs). Innovative ones include a computer, a tablet, a mobile phone, the Internet, etc. But, unfortunately, as evidenced by the analysis of scientific sources, empirical studies, their ability to form a successful pupil is used only partially.

The textbooks for primary school (“Literary Reading”, “Ukrainian Language”, “Mathematics”, “I am in the World”, “I Explore the World”) were analyzed in terms of the success problems reflected in them. Of all the educational books, only in the textbook by Nadiia M. Bibik “I am in the world” for the 3rd grade various aspects of successful activities are sufficiently thoroughly presented. In particular, the social and value orientation of certain goals (the story “What to be?”), the formation of the qualities of successful person (“Human virtues”, “How to succeed”) is reflected. After reading these stories, primary school pupils learn that a person is born to leave a trace behind himself/herself – in memory, in the hearts of other people; need to learn to live for people; to achieve success in life one needs to be hard-working, persistent, not postpone what can be done today, and even anger and rudeness prevent you from achieving a desirable (Bibik, 2014, p. 26, 29, 33, 70). Here is an example of the inventor Edison, who was an extremely hard-working man. There was a ninety (!) per cent of work in the sweat of his brow reflected in his inventions. The rest relate to talent, inspiration, intuition, and other coincidences (Bibik, 2014, p. 29). In this textbook, the economic aspects of success (economy, thrift) are reflected (Bibik, 2014, p. 74). However, in general, in educational books for the primary school, the problem of success is reflected rarely, fragmentarily without respect to the principle of continuity. We did not detect the texts where the children were taught the art of defining goals and analyzing their achievements, overcoming obstacles, how to communicate properly, to treat time with cautious, to help friends, although such knowledge is essential for the formation of a key competence for life – the ability to study.

The fragments of the materials on success are partially presented in fiction, children's periodicals.

In periodicals and books, Ukrainian folk art is presented, in particular, the proverbs, sayings, acting on the development of a child completely opposite. On the one hand, they warn against ambitious plans: "Who flies high, falls low", and on the other, they call for persistent work that suits the vocation.

There are extremely few stories that would form the winner, the builder of the Ukrainian state.

In Ukraine (and this is proved in (Danyliak, 2017; Semeniako, 2016)) periodicals, fiction give way in the struggle for a little user to television, a computer, a tablet, a mobile phone. Unfortunately, there are not so many examples of success. In addition, there is no substantiated system of work for the formation of the success of a primary school pupil by media tools.

The analysis of media tools for the formation of success allows us to conclude that it is necessary to create a new media product that would be interesting, instructive, would meet modern trends in achieving success. We have created praxeological tales – fairy tales in which animals share their recipes for success.

2.2 Praxeological Tale as a New Means of Forming a Successful Pupil

Until recently, there was the rule (popular among people and broadcast in the media) that strong authoritarian persons who had no pity or compassion for others became successful. Only business and nothing personal – the heroes of the movies like to repeat. However, such rules of life are survivals of the last millennium. Modern research (Grant, 1972; Kukk, 2017) proves that those people who care about others become successful the fastest. In particular, the Christopher Kukk's book points to a common mistake of children who believe that it is impossible to be successful and help people at the same time (Kukk, 2017, p. 16). That is why the society is becoming so hostile. However, exactly sensitivity is that value that contributes to the achieving the goals. There is a biological basis for such a conclusion. Studies of the DRD4 gene, which is responsible for dopamine production, show that the level of success in school depends on the atmosphere of sensitivity in the classroom (Kukk, 2017, p. 12). Cooperation, but not competition, has been a leading factor in evolution. The society in which there is a mutual support has better chances of prosperity and survival.

These and other trends of success are reflected in praxeological tales. In particular, a fairy tale "The Best in the Forest" is about the Striped Tiger, who had many friends: a Hare, a Squirrel, a Hedgehog, an Elk, a Wolf, a Wild Boar and other animals. The Striped Tiger helped them all and received gifts from them from time to time. Everyone felt comfortable, until one day an Owl decided to organize a competition in order to identify who is the fastest, the prettiest and the smartest of all... That's when the real battles broke out.

All possible titles in the competition among other residents of the forest were won by the Tiger. He was the fastest, the best at long jumping, the most handsome and the smartest.

The beasts began to envy. The Fox decided that there was some monkey business and accused the Tiger of bribing the judges. The Wolf was desperately looking for the gang ready to pour green paint onto the fine Tiger's fur in order to prevent him from boasting. And the Elk was gossiping about the Tiger as not being the smartest.

The Tiger found himself on the crossroads, felt puzzled whether to get upset or to be happy. How many friends he had lost, and how many enemies he made. The Owl advised what to do: continue to do good and the forest will change for the better (Kuzma, 2019).

So, the main lesson of the fairy tale is to help friends, despite their envy, unjust accusations and actions. He who is the winner, and even though usually faces difficulties, should help his friends even more.

An important rule of success – to do good deeds – is also embodied in the fairy tale "How to become a king of beasts". The fairy tale tells about the little Bear Cub (awkward, unskillful). He wanted to become successful and went to ask for a Lion's, the King of Beasts, advice.

And he got the answer: "You won't believe it, Cubby! But I went through that all like you when I was a kid. Other animals did a number on me too. And then I decided to help someone every single day, someone who is more vulnerable than me. At first, I helped a Mouse, then – a Squirrel, then – a Fox and afterwards – a Wolf. And I felt myself so strong that now I'm not afraid of any beasts!!!" (Kuzma, 2019).

Children learn that everyone has his/her own path to success. But it cannot be overcome without good deeds. You can become successful, authoritative by helping friends, those who find it difficult to overcome obstacles.

However, in the process of forming the pupil's success, the praxeological tale is only one element of the system complex work that needs to be done. Grounding the system of work on the formation of the primary school pupil's success using traditional and innovative media tools, including praxeological tales, remain relevant.

2.3 Model of the Technology of Forming a Successful Personality of a Primary School Pupil during Media Education Implementation (Using Praxeological Tales)

To determine the level of formation of a successful personality of primary school pupils, to prove the work system in this direction, using media education, a study involving 160 pupils of schools in the cities of Ternopil, Khmelnytskyi, and Mukachevo was conducted. The results of this research were highlighted in the article (Tereshchuk et al., 2019).

Pupils were asked to answer the questionnaire.

A list of questions and answers to them (children could choose several answers to questions 2, 4, 5) is shown in table 1.

Therefore, it was found that 85.6% of children consider themselves successful (almost the same number consider their parents to be successful, since for 73% of the respondents their parents themselves serve as examples of success), but only a third of the respondents properly understand the concept of “success” (achievement of the planned result), and another third is mistaken in the interpretation of “success”, considering that a successful person is one who has many activities, regardless of the result they get. According to the respondents, the leading qualities necessary to succeed are self-confidence, diligence and persistence. At the same time, before the forming stage of the experiment and reading praxeological tales, pupils did not mention sensitivity as a quality necessary for success.

Positive aspect may be found in the fact that mom and dad serve as an example in achieving success to their children. But, unfortunately, rarely (for 6.9% of children) it is a teacher. Children receive information about their success mainly from television programs, the Internet and from teachers. This result is not surprising since television and the Internet are the most popular media among pupils. However, in the context of achieving success, the need to improve the content of textbooks, increasing interest in children’s periodicals, writing and reading fairy tales on the themes of success, raising the role of sensitivity, kindness as qualities necessary for achieving goals, as well as system work of parents and teachers, aimed at creating media production by children, which would aim them at success.

The analysis of educational and methodological publications, scientific literature, children’s media, empirical research has shown the need for improving the technology of formation of a successful personality of the primary school age pupil during media education implementation (Tereshchuk et al., 2019), first of all due to creation in class teams the environment of sensitivity, kindness; studying, independent writing of praxeological tales. This technology ensures systemic work, the relevance of which is revealed at the stage of the survey of children. In modern science, technology is usually referred to as information and communication and media education technologies. However, it is also advisable to call technology as such a learning process, which has the characteristics of technological feasibility: systemic, diagnostic, algorithmic, reproducible, predictive (the results of an activity match a certain goal), as well as the following structural components: conceptual and target, content, procedural and result-analytical.

To substantiate the diagnostic tools of the investigated technology, which allows us to check whether a high and sufficient level of formation of a successful personality of a primary school pupil is ensured, the work of scientists on diagnostics of competences of primary school pupils have been analyzed, in particular media literacy, as well as the results of empirical research.

In the technology under study, the criteria for the formation of a successful personality of a primary school pupil during media education implementation are determined the value-oriented, cognitive and communicative, activity and creative, evaluative and analytical (Tereshchuk et al., 2019). Characteristics of the indicators of the levels (high, sufficient, low) of the formation of a successful personality of primary school pupils during media education implementation in accordance with the justified criteria are reflected in table 2.

The pupil of a high level of formation of a successful personality can set goals, establishes the relationship between the success of the heroes and their values; is aware of the main concepts of success, the stages of successful activity, communicates well on the topic of media success, demonstrates the positive dynamics of educational achievements; models successful heroes, writes small and creative works, fairy tales on his/her own, creates projects and drawings, worries about his/her health, without abusing the length of contacts with the media, uses media innovations to improve the level of success; adequately determining the level of success, determines the prospects of self- development using the ideas of media education.

A pupil of a sufficient level, unlike a representative of a high one, makes insignificant mistakes in

Table 1: List of questions and answers of the pupils to a questionnaire.

Question content	a)	b)	c)	d)	e)	f)	g)	h)	i)
1. Who do you consider as a successful person?	earning a lot of money 16	achieving what was planned 50	respected by other people 36	has a lot of different activities 58	other variants				
2. What features are inherent to a successful person?	self-confidence 95	persistence 92	diligence 90	sociability 23	other features (write them)				
3. Do you consider yourself a successful person?	Yes 137	No 23							
4. Who is the example for you to succeed in?	hero of a fairy tale or a story (write who) 16	person you heard about from the TV (write who) 11	mom, dad 117	a teacher 13	there is no example to succeed 3	other variants			
5. Where do you get information about success and successful people from?	school textbooks 17	children's magazines and newspapers 6	fiction 6	TV programs 51	radio programs 1	the Internet 48	teachers 45	parents 32	Theatre performances 6
6. Choose your sex	Male 82	Female 78							

goal-setting, establishing the relationship between the success of the heroes and their values; in the interpretation of concepts in the field of success and successful activity, talks about the success of heroes in the media depending on the situation; the level of educational achievements is either unchanged or a slight increase is observed, creates media production (fairy tales) on the topic of success with the help of adults and peers, situationally showing creativity, does exercises periodically and adheres to the success tips found in the media, sometimes violates media usage rules; makes errors, defining the level of success, defines the prospects of self-development using the ideas of media education with the help of a teacher.

As for the low-level children, they are not able to set goals, do not track the connection between the hero's values from the media and his success, have elementary knowledge of success and successful activity or lack of this knowledge, the level of academic achievement is either unchanged or decreasing, has no model for imitation, sometimes creates a media product about success with the help of adults without creativity, often violates media usage rules, cannot and does not want to adequately determine its level of success and the prospects of self-development.

The feasibility of some of the indicators can be doubtful for some reasons. For example, why it is so important for a successful person to follow the rules of safe conduct while working with a computer; restrict yourself to accessing modern technical devices: a tablet, gadgets, a mobile phone. However, the very safe, rational use of the media makes it possible to preserve the physical, mental, spiritual health that is necessary to succeed.

To determine during the experimental study the levels of the formation of children's media literacy, a set of diagnostic methods was proposed: observation, questionnaires, surveys, analysis of the products of the child's activity (modeled ideal, project about success). Ultimately, the level of formation of media literacy was determined on the basis of the expert judgment method (the experts were a teacher, a representative from parents, the pupil, who carried out self-assessment). In this case, the child was able to gain maximum 2 points on the level of expression of the motivational and value criteria indicators; 4 points – cognitive and communicative with activity and creative; 2 points – evaluative and analytical (total 12 points). Representatives of the high-level gain from 9 to 12 points; medium – from 5 to 8 points; low – from 1 to 4 points. This corresponds to the traditional three-point scale (3 points – high, 2 – medium, 1 – low) of the formation of competencies.

After conducting the confirmatory experiment, it

Table 2: Criteria and indicators of the formation of a successful personality of pupils of primary school age.

<table>
<tr><th>Indicators of the formation of primary school age pupils’ progress</th><th>Criteria for the formation of a successful personality</th></tr>
<tr><td>Setting the goals (determined, determined without complying with the rules of goal setting, non-determined);
the level of differentiation of moral and ethical values, judgments about the achievement of success (based on the definition of good and evil characters in the media, good and bad deeds; qualities that allow becoming successful): deep evaluative judgments, different degrees of the depth of evaluative judgments, evaluative judgments about the behavior of the characters of the media are largely absent.</td><td>Valuable and target</td></tr>
<tr><td>Level of awareness of the types and functions of the media;
level of awareness of success, stages of successful activity;
level of communication on topics of success in the media (high, sufficient, low ability to polysubject interaction)
the dynamics of educational achievement levels.</td><td>Cognitive and communicative</td></tr>
<tr><td>Activity level of actions (high, medium, low);
the level of creative activity and independence during the creation of media products (first of all fairy tales) on the theme of success (the ease of inventing constructive ideas and their independent realization, situationally in the production of creative ideas and implementation with the help of adults and peers, the rarity in the production of constructive ideas under the influence of adults and peers);
the level of realization in the life of innovations from the media about success: overcoming obstacles, performing exercises to increase the success rate (constantly, occasionally, never);
the level of formation of the ability to adhere to the rules of safe behavior when working with a computer; restrict yourself to accessing modern technical devices: tablet, gadgets, mobile phone (high, sufficient, low).</td><td>Activity and creative</td></tr>
<tr><td>Analysis of own level of success (adequate with argumentation, with errors in the argument, overestimated or undervalued without arguments);
setting the prospects for increasing the level of formation of success (expressed skills, partially expressed, absent).</td><td>Evaluative and analytical</td></tr>
</table>

was found out that 17 (10.6%) children are at high level, 78 children (48.8% – on medium), 65 children (40.6%) – on a low level of formation of a successful personality. It was found that the level of success could be higher due to the development of media competencies and the positive dynamics of educational achievements.

The analysis of the results of the confirmatory experiment, scientific and educational and methodical sources made it possible to improve a model of the technology of formation of a successful personality of a primary school age pupil during media education implementation, supplementing it with an innovative media product – a praxeological tale (figure 1).

Its purpose (formation of a successful personality of a primary school age pupil) corresponds to legislative acts, educational concepts, the State standard of primary education. Based on the main principles

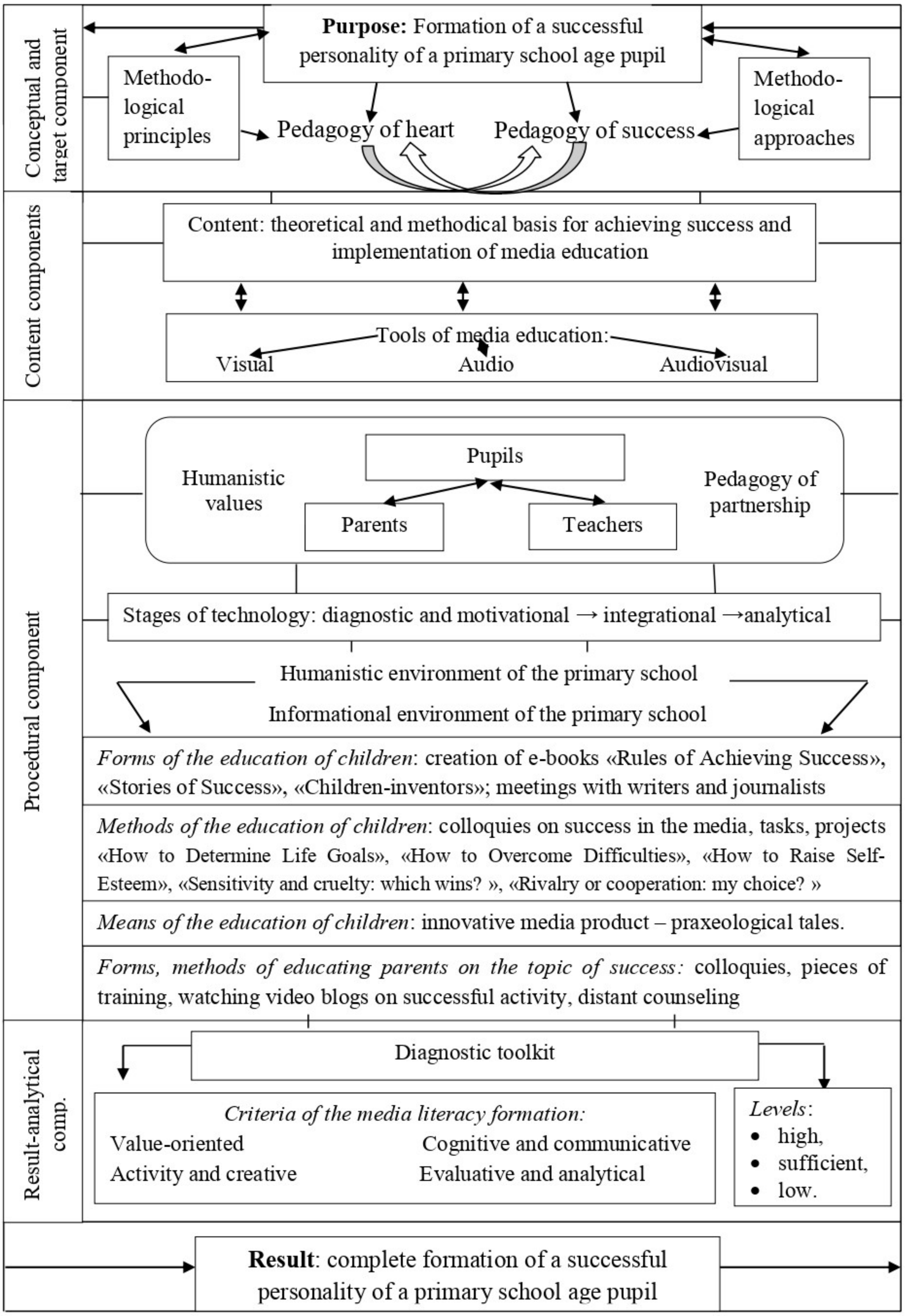

Figure 1: Technology of formation of successful personality of a primary school age pupil during media education implementation (using praxeological tales).

of these documents, methodological approaches (systemic, personal, humanistic, informational) and principles are determined (respect for national traditions, the priority of moral and ethical values, aesthetic inspiration). The model of technology reflects the need for the implementation of the pedagogy of the heart and the pedagogy of success, the main ideas of which are grounded in (Łopatkowa, 1992; Sukhomlinskii, 1962). In our study, the implementation of the pedagogy of heart means that every child should feel the love and care of teachers, parents and classmates: a minimum of competition and maximum of trust, and confidence in the success of each child; at the same time, each pupil feels the need to help peers, older people.

The content component of the technology embodied the theoretical and methodological foundations of success, media education tools. The elements of the procedural component are the algorithm of the actions of the participants of the pedagogical interaction (pupil, teachers, parents) acting on the principles of partnership pedagogy; forms of education for children (the creation of electronic books "Rules of Success Achievement", "Stories of Success" that ensure continuity in the formation of success), methods (conversations about media success, exercises, projects "How to determine life goals", "Sensitivity and cruelty: which wins?", "Rivalry or cooperation: my choice?", "How to overcome obstacles", "How to increase self-esteem") and forms and methods of working with parents (conversations, pieces of training).

Diagnostic tools (criteria, level indicators) make it possible to verify the effectiveness of the technology under study.

2.4 Organization and Analysis of the Results of Experimental Research

In order to test the effectiveness of the designed technology, a forming experiment was carried out during 2018 (the first stage, which involved the introduction the technology of formation of successful personality of a primary school age pupil during media education implementation) (MON, 2019); 2019–2020 (the second stage, during which the improved technology of formation of successful personality during media education implementation was introduced; it was based on the use of praxeological tales as innovative media products, improving the moral and psychological climate in the children's team, strengthening the humanization of pupil relationships).

Since it is impossible to investigate all the types of activities involving children (someone is successful in one activity, and someone else in another), we have stopped on the leading types: studying, media education activities of the primary school children and their self-improvement activities. Control (106 persons) and experimental (104 persons) groups of the third-grade pupils (four classes in each group) of comprehensive schools and educational complexes of Ternopil, Khmelnytskyi, Mukachevo were formed, and the level of formation of their success was diagnosed (the results of the diagnosis are presented in table 3). Traditional forms and methods of forming success were used in control groups, in experimental, however, the developed technology, which provides for the strengthening of the humanization of relations between pupils; praxeological tales as an innovative component, was introduced.

The implementation of the technology was preceded by a preliminary work with the teachers of the experimental classes that received a specially designed educational methodological textbook for raising their level of competence in the field of educational technologies, in particular, media education, information and communication, and the organization of successful activities (Kuzma, 2019; Łopatkowa, 1992; Yankovych et al., 2020). For teachers, colloquies and counseling were conducted. Students of Ternopil Volodymyr Hnatiuk National Pedagogical University and Khmelnytskyi Humanitarian and Pedagogical Academy were involved in the measurement of the results of the study.

As the technology provides for the formation of a successful personality of primary school pupils, along with the implementation of media education, the formation of key competences for life, in the experimental classes, pupils' knowledge of the media, their types and functions, information search, copyright, safe use of digital media, media communication ethics etc. has deepened.

Differences in the formation of a successful personality between control and experimental groups of children were revealed during the lessons of "Literature Reading", "Ukrainian Language", "I Explore the World". In the process of studying each subject in the experimental classes, attention was focused on the problems of success (for which the corresponding texts were selected). Particular attention was paid to the ability to overcome obstacles and the ways to overcome difficulties were discussed. During the experiment, acute topics were considered, in particular about envy and sincere joy for the success of friends, whether it worth to create an ideal and follow it, etc.

The most effective forms of working with primary school pupils were the creation of electronic books on successful children, watching films about the suc-

Table 3: Dynamics of the formation of successful personality levels of primary school age pupils.

Levels	Control group		Experimental group	
	Before experiment	**After experiment**	**Before experiment**	**After experiment**
High	11 (10.4%)	13 (12.3%)	10 (9.6%)	24 (23.1%)
Sufficient	51 (48.1%)	54 (50.9%)	50 (48.1%)	59 (56.7%)
Low	44 (41.5%)	39 (36.8%)	44 (42.3%)	21 (20.2%)

cess of people with special needs, including the author of the book "Life Without Limits" (Vujicic, 2012) an American Nick Vujicic, Italian singer who lost his eyesight, Andrea Bocelli, a Ukrainian artist Dasha Bezkosta, who having infantile cerebral palsy, draws pictures using her toes, etc. Effective methods include an analysis of the behavior of heroes of stories, praxeological tales; the justification of which features of the character can help to achieve success, creation and discussion of various projects, primarily "How to determine life goals", "Sensitivity and cruelty: which wins?", "Rivalry or cooperation: my choice?"

In both control and experimental groups, the formation of key competencies among pupils took place in accordance with the Concept of the New Ukrainian School (Elkin et al., 2017), the State Standard of Primary Education (MON, 2017). Their formation is undoubtedly an important factor in achieving success. So, during the experiment, we predicted an increase in the formation of a successful personality in both control and experimental groups, which eventually happened.

According to the results of the forming experiment, 23.1% (24) of the respondents of the experimental groups were at a high level; 56.7% (59) – at a sufficient level; 20.2% (21) – at a low level.

In experimental groups, the percentage of children with a high level of successful personality development (from 9.6% to 23.1%) has increased, and the percentage of a low level has decreased (from 42.3% to 20.2%).

In control groups, there was an increase in the number of children of the high level of formation of a successful personality by 1.9%, of sufficient – by 2.8%. The number of low-level representatives decreased by 4.7%.

The increase in the formation of a successful personality of pupil in experimental groups was due to skillful goal-setting, awareness of the value of media education for life success, the formation of knowledge about success, successful activity, the creation of media production on successful activities – fairy tales about success, e-books "Rules of Success", "Stories of Success", "Children-inventors"; the analysis of works in which a life ideal is represented; projects "Sensitivity and cruelty: which wins?", "Rivalry or cooperation: my choice?", as well as due to children's compliance with the media usage rules; also through the study of praxeological tales, the creation of an environment of mutual support and assistance in the classroom. Positive impact on the results of the experiment also had the introduction of the pedagogy of heart, humanization of relations in the classroom, increasing the level of formation of children's teams, raising the level of media culture of parents, their awareness of the problems of upbringing a successful child.

Indicators of pupils who were less subject to changes are the dynamics of the levels of academic achievement of pupils; the level of their communicativeness and creativity, the definition of the prospects for self-development.

3 CONCLUSIONS AND PROSPECTS FOR FURTHER RESEARCH

Formation of a successful personality of a primary school pupil during media education implementation using praxeological tales helps to solve several actual tasks: to increase the level of media culture of a pupil, to form key competencies for life, to prepare a child for the life's self-realization, which in the end should contribute to the strengthening of the Ukrainian state in future.

Praxeological tale is a fairy tale, which reflects the basic rules, factors of achieving success. The connection between success and sensitivity, humanity, providing support to those who need it (that one who shows humanity, the ability to help achieves success faster and easier) is one of the leading ideas of these tales.

The research has proved the effectiveness of the implementation of the technology of formation of a successful personality of a primary school age pupil during media education implementation using praxeological tales. In experimental groups, the percentage of children with a high level of successful personality development (from 9.6% to 23.1%) has increased, and the percentage of a low level has decreased (from 42.3% to 20.2%).

Praxeological principles of the formation of the content of primary education are the prospects of further research.

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Using Personal Smart Tools in STEM Education

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Abstract: Under STEM education, a lot of computer-based methods were used to improve motivation, personalization and enchaining of the quality educational process. However, the attention has not been devoted to using of the IoT and smart tools to measure parameters during educational research process. It stands even more relevant due to the growth of the amount of the smartwatch/band used by people. The methods of using personal smart tools under STEM classes and researches have been developed in the study. Colmi land 1, Xiaomi Mi Band, Samsung Smart Fitness Band, Xiaomi Mi Smart Scale were used to test the proposed methods. Firstly, As is – To be Business Process Model and Notation method was used to evaluate changes in educational processes for both, pedagogical and technical points of views. It is proven that proposed methods are characterizing by the higher efficiency compare to classical educational process. For the first time, the techniques of using personalized smart tools to measure during the experiments are described in the paper and ready to use.

1 INTRODUCTION

The acronym STEM has published by the US National Science Foundation in 2001. The acronym SMET was previously used, but has modified. As a separate area of didactics, STEM stood out in the USA in 2009 with its "Educate to Innovate" program. However, in Ukraine it only start to providing and its using is much less compare to traditional educational approach (Shapovalov et al., 2020; Kramarenko et al., 2020) even contrary its advantages.

A significant attention at STEM lessons is to increase the motivation of students. Also, such lessons are developing many skills such as communication, data processing and project management, which largely depend on information technology.

In general, STEM approach tools in education classified into tools, software and specific modern tools. The tool part can be divided into: digital laboratories, digital equipment, mobile phone, mobile phone with additional sensors, smart tools. The software like process calculators, modelling environment, VR video, VR applications (Joiner, 2018), AR applications (Martín-Gutiérrez et al., 2015; Dziabenko and Budnyk, 2019; Jong et al., 2014), educational environments (Joiner, 2018), 3D printing, 3D modelling tools (Sala, 2014), etc. However, in our opinion, the Internet of Things (IoT) has high untapped potential in education due to several advantages such as using cloud computing and calculation, and visualization of data measured or captured by devices. Due to those devices connected to the personal ecosystem, they provide personalized data.

Internet of Things (IoT) differs from cloud services because it can use cloud servers to provide its activity. Internet of Things includes M2M – machine-to-machine connection method (without human involvement) by measuring and interaction. The most perspective to use under STEM education classes is personalized smart tools.

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Smart tools are tools that can be part of the IoT and have automatic algorithms for processing information and can notify about a change in a specific user parameter IoT uses cloud services to provide a connection between instruments connected through internet. Smart tools can be compared with IoT. Smart tools as IoT are electronic devices connected through the Internet or Bluetooth, NFC and send measured (fixed) data into the cloud, where it saves. User can get information using cloud from any place using Android/iOS application or web-interface. The main advantages of its use are personalization (which is that personal connection of device in personal page of application/web-interface). Distinctive features of smart tools are:

- measures actual performance
- measures other calculated indicators
- analyzes the data
- states of necessary changes or displays a case that is important to the user

Smart tools include fitness bands (tracks), smartwatches, smart scales, smartphones. The most perspective to use under the education process are smartwatches/bands, scales, temperature sensors, humidity sensors, specific plant sensors. Relevance of the research proved by the increasing of the amount of using personal wearable device due to much higher affordability and simplicity of them (Gubbi et al., 2013). There was an expected jump from 100 million in 2016 to over 373 million in 2020 (Pal et al., 2020) and even up to 1.1 billion in 2022 due to transformation from 4G to 5G of mobile internet connection (Holst, 2020).

2 LITERATURE REVIEW AND PROBLEM STATEMENT

In general, as was noted before, the smart tools have been using widely in everyday life, sport, medicine and healthcare. For example, wearable devices use monitor state of the patients in clinics to alert the doctors (Stradolini et al., 2017).

IoT technologies and Cloud Services are becoming more and more popular for educational purposes (www.al-enterprise.com, 2018). IoT will significantly improve the quality of education. Implementation of IoT in education will create new ways to learn by supporting more personalized and dynamic learning experiences. IoT will give teachers new methods to explain the material for the lessons (www.al-enterprise.com, 2018; Bakla, 2019). Also, IoT will be an excellent opportunity to provide the unique lessons to people with some disabilities (Mcrae et al., 2018).

For example, Singapore has implemented the Intelligent Nation Master plan since 2006, in which technology-supported education is a significant part (Hua, 2012). South Korea had the smart education project, the main task of which are reforming the educational system and improving educational principles (Zhu et al., 2016). Australia collaborated with IBM and designed a smart, multi-disciplinary education system (Rudd et al., 2009). Ukraine has provided new school program concept, in which they underline the importance of smart tools and E-learning (Elkin et al., 2017).

Some authors create different education systems based on wearable devices and IoT technologies (Liang et al., 2019; Mavroudi et al., 2018). This education systems integrates with the IoT tools and special apps that can create more interactions between teachers and students in class while providing more innovative learning possibility. Also, IoT can inspire school students and increase their concentration in the classroom during the lessons (Pervez et al., 2018).

Also, have shown that the use of IoT technologies in the educational process will improve the quality of learning. Besides, the result of their scientific research showed that the using of IoT technologies significantly increase overall opportunities for the realization of creative abilities for both teachers and students.

Previously it was proposed to use such technologies like using of mobile Internet devices in the formation of the general scientific component of bachelor in electromechanics competency in the modelling of technical objects. In this work they have underlined that using of mobile Internet devices is a perspective way to improve the quality of education in general. Also, the authors have proposed different tools to work with, as an example: mobile augmented reality tools, mobile computer mathematical systems, cloud-oriented tabular processors as modelling tools, mobile communication tools for organizing joint modelling activities and more (Modlo et al., 2020).

Using the Internet of Things in education is an excellent function for connecting and educating students. Different researchers at their articles have tried to implement smart tools to provide various services in smart campus accessible in handheld devices by doing ideal connectivity among multiple things. Proposed system must do a collection of data from the classroom, just not only presenting information to students and collect from their interaction. Also, these data can be uploaded and can be opened by using smart e-learning application. At smart classrooms, tools are aimed at either real-time monitoring of teaching space or on smart tools that support students, in which multiple functions are brought together (Veeramanickam and Mohanapriya, 2014; Valks et al., 2019; Cebrián et al., 2020).

At the same time, the use of IoT is promising, but not widely used. Overall, there is no complete, systematic list of techniques that can be used in class. For today, the most popular smart tool is a smartphone, but in this work have been proposed methods which will use smart scales and bands/watches.

3 METHODS OF ANALYSIS

The study conducted using the methods of theoretical and empirical research: analysis and synthesis to determine the main trends in the use of IoT in the world and the educational process. Conceptual-comparative analysis has used to study the best pedagogical experience. Structural-system analysis and synthesis also have used to build a theoretical model of as is-to be process. The following devices were chosen for our experiment: Colmi land 1, Xiaomi Mi Band 4, Samsung Smart Fitness Band, Xiaomi Mi Smart Scale 2.

To provide analysis of proposed teaching process modification, firstly, “As is-to be” method (Visual Paradigm, 2016; Fossland and Krogstie, 2015) has been used. The method based on using of Business Process Model and Notation (BPMN) (BPMN, 2013) to note the current process and for proposed approach for both, technological and pedagogical process business analysis. BPMN provides a decomposition of the complex processes to simple elements and connection of them by arrows to interpret the total process. Also, BPMN uses “lines” to decompose elements of the process by the executor, for example, teacher and student.

In general, BPMN is using in business analysis, but taking into account its specifics, it will be suitable to use in scientific work to justification of expediency of using proposed approaches. Besides, there very few researches have been used BPMN to describe processes in education (Morais et al., 2020; Wiechetek et al., 2017).

To evaluate the content of devices that can measure the concrete parameters, hotline service and its filters were used. The following formula $N/N_a \times 100$ was used for this purpose, where N – specific gadgets with needed parameters, N_a – all gadgets of the selected brand.

4 RESULTS AND DISCUSSION

4.1 Existing IoT Ecosystems

The most popular devices are those that are part of a smart home and are connected using either Wi-Fi or Bluetooth protocols. The most common types of devices are: scales, watches, fitness trackers. The leading manufacturers of these types of products are: Samsung, Xiaomi with Amazfit/Huami sub-brands, Apple, Google Nest and others.

Samsung smartphones can become a central link in the entire ecosystem. From a phone, you can control your watches, devices, headphones, write some notes and then continue working on them on the other device. At the same time, all synchronisation is seamless. The main thing here is the availability of the Internet. But even without the Internet, you can exchange data between your tablet and smartphone using Samsung Flow. The heart and brain of their developments are Bixby 2.0, an intelligent assistant who will easily connect to Samsung devices. Bixby 2.0 is the central hub of the IoT ecosystem, learning from daily interaction with users’ devices to better understand and anticipate all your needs (Mesquita et al., 2019; Këpuska and Bohouta, 2018).

Today more than two hundred companies and start-ups are located under the Xiaomi, each of which is responsible for its type of product. The Amazfit brand is developing fitness trackers and smart clocks. Ninebot is adding to the company’s range of personal electric vehicles, and SmartMi develop smart home appliances. Wearing electronics has long since ceased to be a curiosity, and today it helps monitor physical activity, sleep quality and overall health for millions of users around the world. Xiaomi could not remain indifferent and, together with Amazfit, has taken its niche in the ranks of smart wearable gadget manufacturers. It is no secret that Xiaomi Mi Band is one of the best and most popular fitness trackers on the market. With each new generation, the fitness bracelet is pumping its capabilities and becoming more functional. Furthermore, it is maintaining a reasonably loyal price tag that provides the gadget with such popularity.

But the company is not in charge of wearable gadgets. Household medical devices such as electronic thermometers, inhalers and tonometers have also found their place in the range of Chinese technology giants. And recently, Xiaomi has begun mastering another area – home simulators. At the moment, among Xiaomi’s simulators, one can find the WalkingPad A1 folding treadmill. There is no doubt that in the nearest future the company will also cover other sports equipment for home sports.

Apple HomeKit and Health app are the platforms, the central purpose of which is to unite all the smart technologies in the home. The HomeKit platform was released by Apple back in 2014 as part of the WWDC conference, and already a year later full-fledged devices based on it began to be available for sale. Starting with iOS 8, Apple mobile devices will be able to manage compatible home appliances and home life support systems. One of the advantages of HomeKit is close integration with the Siri virtual assistant. HomeKit can be controlled by voice commands, which opens up truly enormous opportunities for home appliance developers and software developers (Mesquita et al., 2019; Këpuska and Bohouta, 2018). Today, third party software has used to control home smart appliances, but a native application has appeared in iOS 10. The programme will be able to take over the management of all Smart Home appliances equipped with the appropriate software. Apple's Health app allows you to monitor your health, daily activity, and provide important information to your family or friends when needed. It is especially critical in the event of an accident or sudden illness, as well as when tracking fitness stress. Health app excellently works with Apple Watch. Apple Watch can measure the level of O_2 in blood and can take electrocardiograms.

Google began taking its first steps towards a smart home back in 2016 when it introduced the first Google Home speaker. It was supposed to be a kind of analogue of Amazon Echo, i.e. it could control home appliances and be used as a multimedia device. The Google Cast application, which used to configure and manage Chromecast devices, has since been renamed Google Home and its functionality has extended to the new column. One of the latest innovations from Google in this field was the Google Home Hub, shown last year. Google Home Hub is a tablet with a display that can combine information about your smart devices in the Google Home ecosystem and display it on a built-in display. In May 2019, Google presented its product Nest Hub Max at a presentation. Unlike Google's Home Hub, it has a camera and added multiplayer functions. Central operating tool of "Google Nest" is "Google Assistant" (Mesquita et al., 2019; Këpuska and Bohouta, 2018). In addition to the devices produced and presented by Google itself, there are a large number of companies that manufacture devices compatible with this ecosystem. Their number has already surpassed 500. And every day, there are more and more manufacturers producing products marked "work with Google Assistant".

However, it seems relevant to analyse the ecosystems of those companies based on the parameters can be measured by concrete equipment. The main parameters used during educational researches are heart rate, blood pressure, ECG, oxygen content, weight, muscle, fat, bone, and water content in the human body. Examples of devices of different companies, that can measure concrete parameters are presented in the table 1.

4.2 Advantages of using Smart Tools in the Educational Process

The main functions of IoT devices in the educational process are defined:

- The *training functions*. The training involves the use of IoT devices in the study of individual subjects, especially STEM subjects directly. Most often, certain types of devices are used as a tool to perform a learning task. They can also be used in the design of research activities and the performance of research tasks.
- The *health-preserving function* involves the use of IoT devices as a tool for monitoring the prime indicators of the body. First of all, to form a healthy lifestyle with the subsequent formation of skills to control physical shape. It can also be used to monitor vital signs in people who need it.
- The *control function* involves the use of devices as a tool for self-control and control by others (parents, managers). Allows control over certain types of activities and the children GPS, especially primary school and preschool children by parents or persons who replace them, if necessary, such control may be carried out by a teacher. It helps to increase the level of self-control, which is supported by the formation of habits.
- The *ergonomic function* involves the use of devices to improve productivity, namely planning, coordinating the use of their own time, and the effectiveness of the actual use of tools that help increase the productivity of each child and the educational process as a whole. Rational use of IoT devices and time allows to control admissible physical, nervous and mental loadings of the child and allows to increase its working capacity.

The use of smartwatches/bands in the learning process contributes to the development of principal competencies:

- *mathematical competence* expressed in the formulation of navigation, calculation of the necessary parameters using indicators created from reasonable years;

Table 1: Examples of devices of different companies, that can measure concrete parameters.

	Samsung	**Xiaomi**	**Apple**	**Google**	**Other brands**
Smart watches/bands					
Heart rate	100% of devices: Samsung Galaxy Watch 1, Samsung Galaxy Watch 2, Samsung Galaxy Watch 3	100% of devices: Amazfit T-Rex, Amazfit Bip S, Amazfit Stratos	100% of devices: Apple Watch Series 1, Apple Watch Series 2, Apple Watch Series 3	N/A	100% Aspolo SmartWatch U8, UWatch U8, SmartYou DZ09
Blood pressure	-(3,9%)Samsung Galaxy Watch 3	- (0%)	- (0%)	N/A	5.5% Havit HV-H1100, UWatch DT88 Pro, Aspolo DT88 Pro
ECG	(0 %)	+ (4.4 %) Xiaomi Mi Watch Color, Xiaomi Haylou Smart Watch	+ (52.5 %) Apple Watch Series 5, Apple Watch Series 6, Apple Watch SE	N/A	7 % No.1 DT28, Lige Smart, Gelius GP-L3
Oxygen content	- (3,9 %) Samsung Galaxy Watch 3	- (0 %)	10,2 % of devices: Apple Watch Series 6	N/A	11.7% Aspolo M1Plus, Aspolo DT35, UWatch E66
Sleep quality (stages of the sleep)	100% of devices: Samsung Smart Charm, Samsung Galaxy Fit E, Samsung Galaxy Watch Active	100% of devices: Xiaomi Mi Band 4, Xiaomi Mi Band 5, Amazfit GTS,	100% of devices: Apple Watch Series 5, Apple Watch Series 6, Apple Watch SE	N/A	100% Aspolo SmartWatch U8, UWatch U8, SmartYou DZ09
Smart scales					
Weight measuring	N/A	+ (100%) Xiaomi Mi Smart Scale 1, Xiaomi Mi Smart Scale 2	N/A	N/A	100% Laretti LR BS0015, HUAWEI Body Fat Scale, AEG PW 5653 BT Black
Muscle, fat, bone, and water content in the human body	N/A	+ (100%) Xiaomi Mi Smart Scale 1, Xiaomi Mi Smart Scale 2	N/A	N/A	100 % Yunmai Mini Smart Scale, Garmin Index Smart Scale, Acme Smart Scale

- *competences in the field of natural sciences, engineering and technology*, which is formed based on acquiring skills in working with physical parameters, vital signs, geolocation data, ability to work with different models of certain devices and their analogues, etc.;
- *innovation* is defined in the formation of skills in the use of leading technologies for personal and public health;
- during the connection process of smartwatches/bands with a smartphone, the students get acquainted with the concepts of “cloud technology”, “synchronization”, “remote access” – the mastery of this knowledge will facilitate the formation of *information and digital competence*;
- *social competencies* manifested in the configuration of the ability to be aware of personal feelings and the ability to listen to internal needs, which is shown in the perceived need to maintain a healthy lifestyle;
- smartwatches/bands encourage students to take accurate measurements of their heart rate, blood oxygen concentration and stress levels – this knowledge allows them to produce *health-preserving competences*.

For example, a pupil can see on his smart clock that negative emotions (anger, aggression) accelerate heart rate. These devices can be used to create motivation for a healthy lifestyle. For example, you can offer students a cup of coffee, an ’energy drink’ and then measure their heart rate. Such experiment will demonstrate the effect of certain substances on the functioning of individual organs and systems.

Smartwatches/bands also have considerable potential for developing useful skills and habits. Most of these devices have a reminder mode. At first, you can set up a notifier that after 40 minutes in a sitting position (while doing your homework), you need to do some exercises. But after 40 repetitions of this sequence, a useful skill becomes a habit that can be reproducing without a smart device.

But smartwatches/bands have the most pedagogical potential in shaping research competencies.

Document "The European Qualifications Framework for Lifelong Learning" (Guest, 2007) determines that a high-level specialist should have research competence in his or her field of knowledge. Research competence is the ability of the acquired education to perform research educational tasks, to carry out research activities aimed at obtaining new knowledge and / or finding ways to apply them, in accordance with the profile of study (Cabinet of Ministries of Ukraine, 2020; Nechypurenko and Soloviev, 2018).

With the help of smartwatches/bands, a student can obtain a large amount of data – this is the stage of acquiring new knowledge. Also, a student can analyse this data with mathematical tables – this is the stage of creating a knowledge system.

It is also possible to use smartwatches/bands to create motivation for learning activities within the STEM approach. For example, students observe the phenomenon of heartbeat acceleration after physical activity, after they will ask a problematic question: Why does it happen? How is the heart activity regulated? And the whole lesson lays out around this doubtful question.

There are also perspectives for using smartwatches/bands for students with special needs. For example, it is challenging to teach a child with hearing disabilities how to measure his pulse, and smartwatches/bands can help to solve this problem.

In this article, we present several methods of using smartwatches/bands during the learning process. These methods can be divided by the time they will use:

a) methods that can be directly used in the learning process at school;

b) methods that ensure long-term experiments, for example, within 24 hours, the application of the latter is relevant to the performance of research work or projects by students.

Thus, the use of the smartwatch/band allows:

- to create motivation for learning activities;
- to create impulse for a healthy lifestyle;
- to develop an information-digital, health care and research competencies.

4.3 Analysis of Proposed Teaching Process Modification

Smart tools are the perspective way to provide transcendent educational experience. For example, students can interact with objects directly, they investigate it necessary by themselves. By using smart tools, students can make different type of activities such as asses level of O_2 in blood, heart rate and more. To create a smart-lesson, it is necessary to achieve connectivity between smart tool and smartphone via specific application, for example, Xiaomi Mi Fit.

During the "As is" for the researching STEM lesson process anticipates that the teacher explains the theory, which is always hard to understand by students, with further explanation of parameters which will affect on the object or process. In all cases teacher will explain an experiment using class board without any research, less often by providing demonstrations, and very rare, will provide group experiment. In those cases, a student doesn't understand the material clearly. Also, skills and competencies delivered using this process will be limited only by specific, laid down in the topic of the lesson, which may be not enough according to the latest international and Ukrainian documents.

Besides, the technical part for all demonstration and group experiment, will be mostly provided manually by students or teacher, and results of it will be calculated, processed and interpreted manually. This time can be used for more beneficial for students teaching process. Thus, measuring starts from choosing the measurer and providing measuring. Obtained data must be notes and written by using of class board or worksheets. Then calculation is provided manually, which, sure may be very useful, comparing to automatic computation. The best effect may be obtained by the combination of both manual and automatic calculation. Obtained data interpreted in graph, board or worksheet. Finally, the graphics and data are analysed. As is process (including technical interaction) is presented in figure 1.

As in "As is" process, the teacher starts classes from the theory and further transferring to more practical oriented part, which is explaining the factors that will affect on some object or process. Also, based on the amount of available smart tools, pupils will have the demonstration, group experiments or personal experiments. Understanding of the materials will be better due to the higher speed of the research. Calculation and graph creation will be provided automatically. Students will work with personal data and graphs. They will understand how to work with graphics and data, and how to use individual wearable smart tool to provide researches which will motivate students to research and will present better usage to health care. During personal experiment, students will have more questions comparing to the as-is process due to higher motivation. And, same as in “As is” process, classes will finish by investigation and discussion of the results.

The main features of the “To be” approach is time-saving and motivation increasing. From a technical point of view “To be” process is significantly more automatic. Only methods of measuring and analysing in this case provides by teacher and students. All analysing process which includes sending measured data to smartphone, saving data, processing data and creation of the graph must be conducted by the teacher or student. The data that is using additional soft can be imported to Excel for further processing.To be process (including technical interaction) is presented in figure 2.

So, in general, “To be” process is more interactive, engaging and beneficial for students, and motivate them to provide personal researches, and learn how to use individual smart gadgets to healthcare, it may save a lot of time to use it more effective. Sure, worth to note, that during “As is” process student teaches how to process the data. And it seems relevant to combine those methods.

4.4 Advantages of using Smart Tools in the Educational Process

4.4.1 Methods Can Be Used during Lessons

Topic: Measure of the heart rate before and after physical activity with smartwatches/bands (figure 3).

Aim: Demonstrate to students that a smartwatch/bands can measure heart rate and effect of physical activity to heart activity.

Equipment: IoT or smartwatch/bands or fitness tracks with heart rate monitoring functions; blood pressure, oxygen concentration (optional).

Experimental procedure: The technique involves the selection of 10 participants of each sex for the study. Each of the participants takes heart rate, blood pressure (optional), oxygen concentration (optional) measurements at rest. Then student must make 20 squats, after he needs to take the estimations one more time. The analysed data, can be both personalised as a graph on their smartphone and in a table drawn on a blackboard, where the teacher finds regularities related to all students (including, sex, weight, age, etc.) and explains them to the audience.

Analyse of data: To analyse the data, we need to find regularities before and after physical activity. Compare actual and relative changes in indicators after physical activity in boys and girls, and we need to find dependencies of other indicators, such as height, weight.

Topic: The effect of sleep duration on heart rate (figure 4).

Aim: Demonstrate to students that sleep duration affects the functioning of the circulatory system. Use personal example to prove to students the importance of sleep and adherence to the daily habit.

Equipment: Smartwatches/bands with heart rate, blood pressure (optional), oxygen concentration (optional), ECG (optional).

Experimental procedure: The research is personalised, so each student carries it out separately. The method foresees changing time regime in two steps. Firstly, students during the experiment must get sleep daily for seven days at 22:00 and get up at 7:00. As soon as you wake up, students provide a measure of the heart rate, blood pressure (optional), oxygen concentration (optional), ECG (optional), as well as the quality of your sleep. After the first seven days of the test, students must get sleep at 23:00 and get up at 6:00 and students provide record the findings, same, as soon as wake up.

Analyse of data: Analyse of date is performing by comparing the heart rate and oxygen concentration in the blood on the first stage (go to bed at 22:00 and get up at 7:00) and executed on the second stage (go to bed at 23:00 and get up at 6:00) with the normal condition. Changes in data must be attached to stress or adaptation state using theoretical knowledge.

The experiment is safe and can conduct regardless of the health conditions. But we recommend that the research supervised by the teacher or adults. Based on the results, it is possible to study adaptation, human comfort areas and stress conditions.

Topic: Determination of differences in muscle, fat and bone composition in men and women (figure 5).

Aim: Demonstrate to students some differences in the muscle, fat and bone composition of men and women. Explain the reasons for such differences.

Experimental procedure: The technique involves the selection of 10 participants of each sex for the study. Each of the student must measure muscle, fat and bone tissue. The analysed data, can be both personalised as a graph on their smartphone and in a table drawn on a blackboard, where the teacher finds regularities and explains them to the audience.

Analyse of data: To analyse the data, it is necessary to find regularities in the amount of muscle,

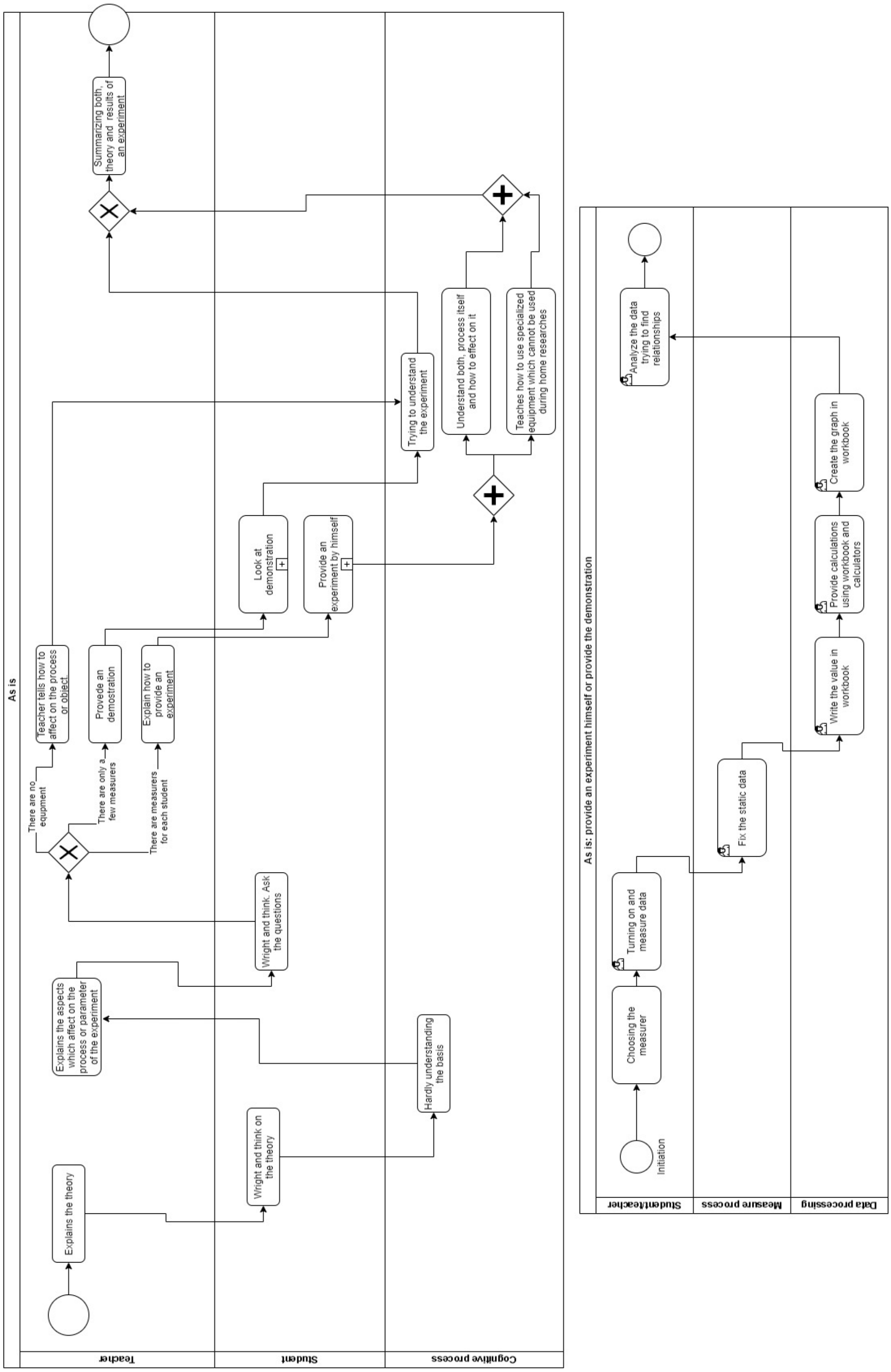


Figure 1: “As is” process (including technical interaction).

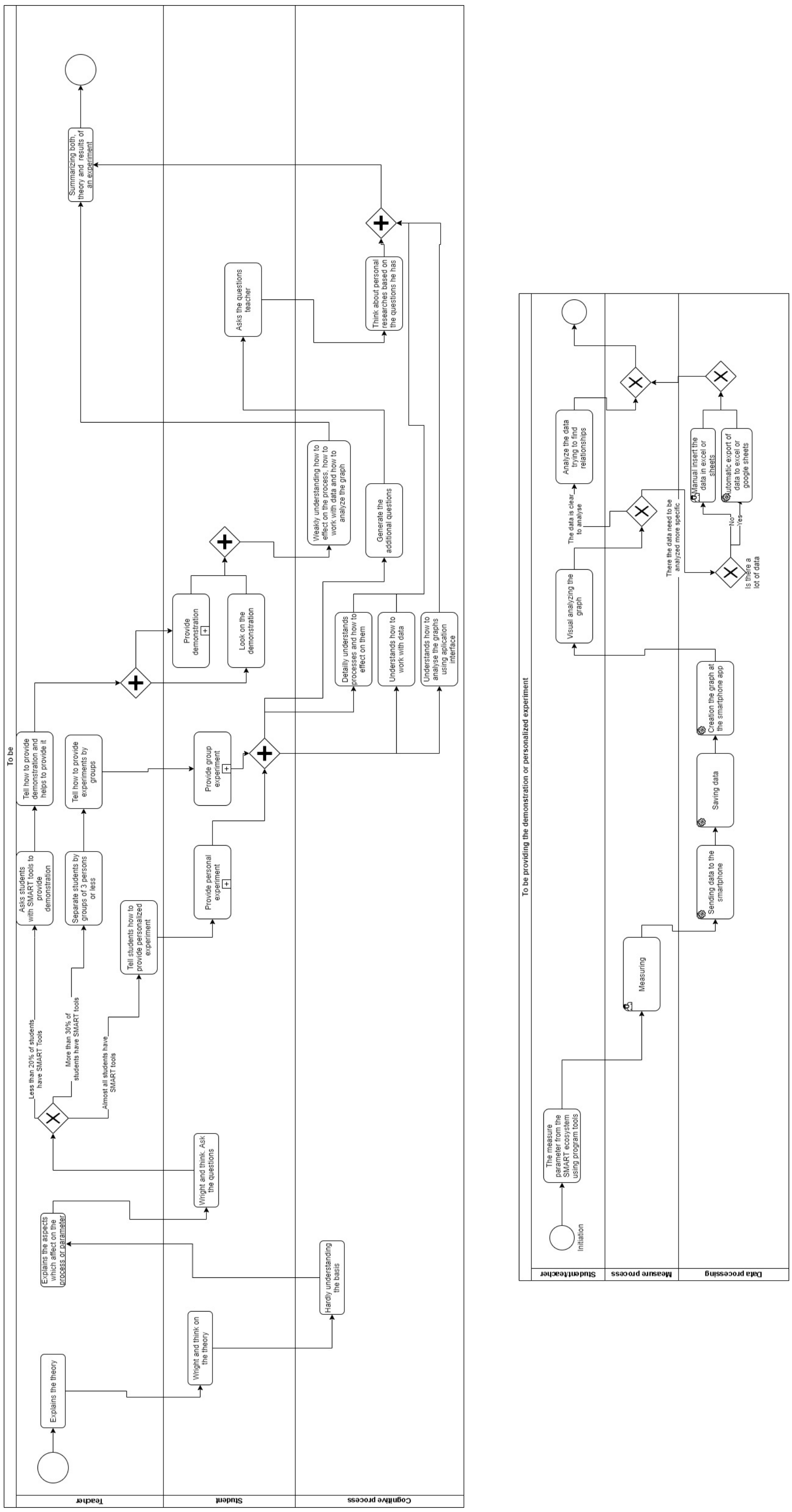
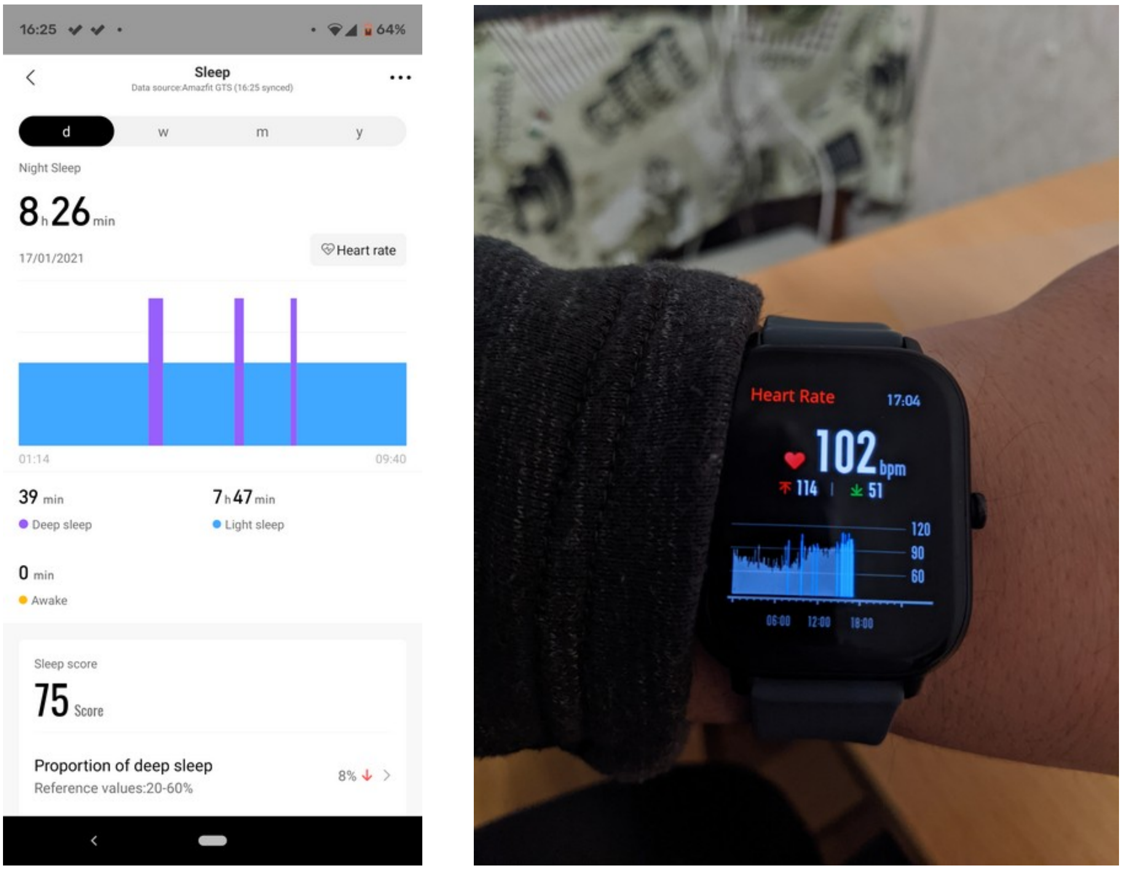


Figure 2: “To be” process (including technical interaction).

(a) (b) (c)

Figure 3: Experimental part of the work (a), heart rate before (b) and after exercise (c).

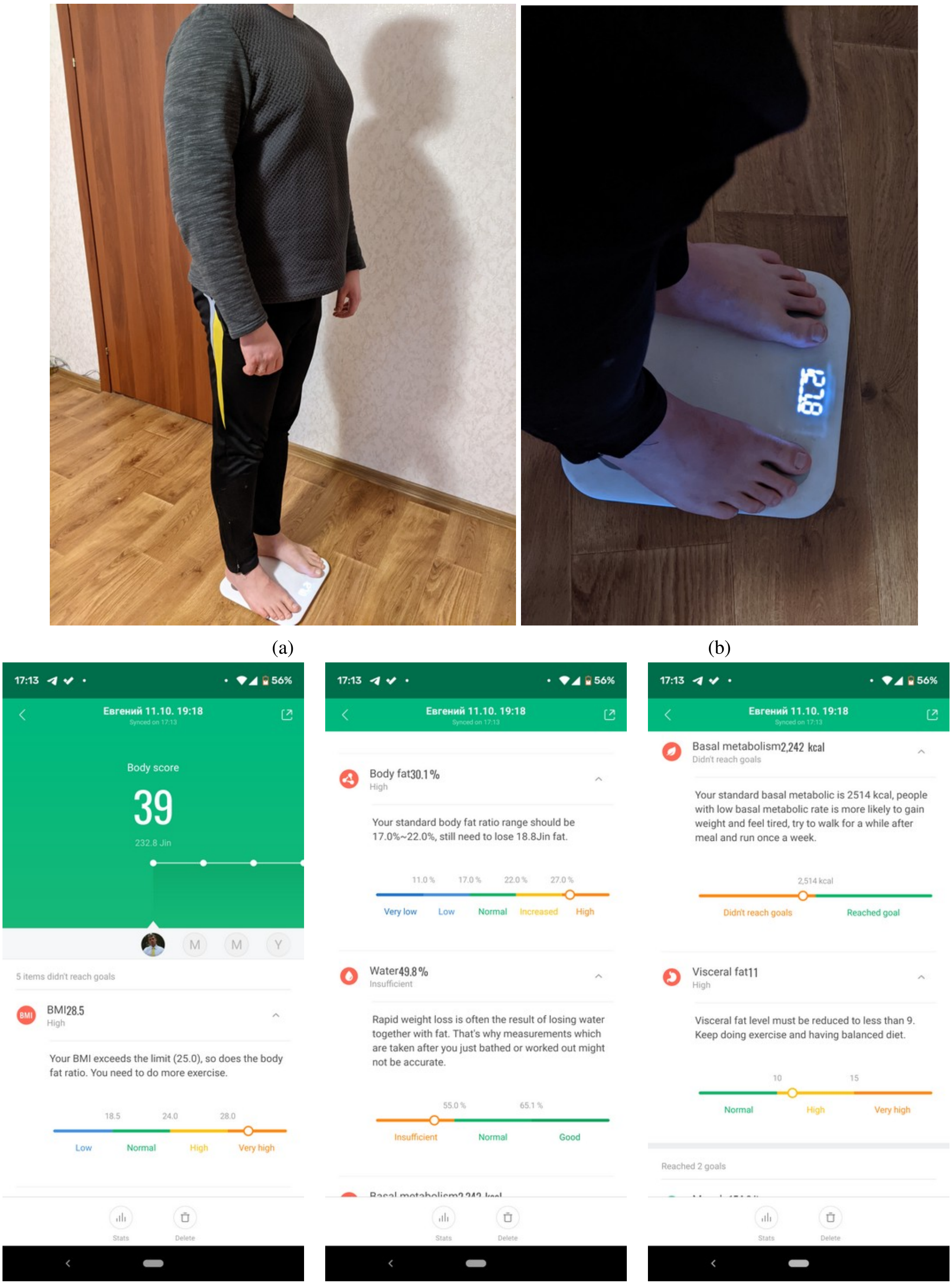


(a) (b)

Figure 4: Interface of smart watch's application sleep tab (Amazfit Zepp) (a) and the result of the analysis (b).

fat and bone tissue and compare the actual and relative speed of change in the amount in boys' and girls' bodies.

It is necessary to mention that the method is simple and promising to use in every school, especially since it does not require sophisticated, expensive smart equipment. At the same time, it is useful because students measure the real indicator, compared to the traditional process, and they also learn to analyse data and graphs on their smartphone. Also, students are more motivated to research after the class. To analyse the data, we need to find regularities in the amount of muscle, fat and bone tissue and compare the actual and relative speed of change in the amount



(a) (b)

(c) (d) (e)

Figure 5: The procedure of weight measuring (a), example of weight displaying (b), interface of integral automatic weight state assessment (c), details of body state (d, e).

of muscular, fat and bone tissue in boys' and girls' bodies.

Topic: Determination of the level of saturation in suspected COVID-19 (figure 6).

Figure 6: The result of oxygen content in blood determination.

Aim: to teach students to measure the level of blood saturation (oxygen concentration) in the blood, which became especially relevant during the COVID-19 pandemic.

Equipment: IoT or smartwatch or fitness tracks with monitoring of oxygen concentration – saturation.

Experimental procedure: Measure your oxygen concentration in blood by smartwatch/band. If the value is less than 95%, consult a doctor immediately.

Analyse of data: This experiment can be performed once, and can be exported to Excel for a long time every day. In a healthy person, the level of saturation is the same and does not depend on any factor.

4.4.2 Methods Performed for a Long Time

Topic: Diet effect on body parameters, especially on the amount of muscle, fat and bone tissue (figure 7).

Aim: Demonstrate to students the relationship between diet and the amount of body fat, to form an understanding of healthy nutrition.

Equipment: smart scale.

Experimental procedure: Firstly, student measure the amount of muscle tissue, fat tissue, bone tissue using a smart scale. Based on the results of measuring the amount of fat, muscle, bone tissue in your body, students define a goal for themselves (for example, to get rid of fat tissue) consulting with a teacher and, based on it, chooses the diet. Students provide daily measuring of the amount of fat, muscle and bone tissue for sixth months, preferably in the morning before meals. The data can be analysed using a smartphone or using an Excel table.

Analyse of data: Students must define the efficiency of the diet and make conclusions about personal fitting of the diet. Students must analyse the tendencies by determining the specific periods (stressed state of the organism and adaptation).

The method can be used in every school, but it is a lengthy experiment. It would be better if the research would conduct under the supervision of a teacher or adults. It can be used as a source for data for research works for students researching contests.

Topic: The physical activity effect on sleep duration and heart rate (figure 8).

Aim: Demonstrate to students the physical activity effect on heart rate and sleep duration.

Equipment: Smartwatch or fitness tracks with heart rate monitoring functions; blood pressure, oxygen concentration (optional).

Experimental procedure: Measure the duration of sleep and heart rate, blood pressure, oxygen concentration (optional) without physical effort before going to bed for a week. After that, 3 hours before sleep, do one of two things:

1. Perform three times thirty squats and three times ten push-ups; repeat the exercise cycle four times a week; leave three days to rest.
2. Perform a 2-4 km run each day for six days per week (1 day left to rest).

Each day students must provide measuring the duration of sleep and heart rate, pressure, blood oxygen level. Enter your blood pressure, heart rate, long and short sleeping phases into the Excel table, and analyse the results.

Analyse of data: Compare the measured parameters before the activities and during "active" week. Define are the quality of long phase of sleep is increased, define the changes of heart rate before sleep. Compare the obtained data to well-being.

The method is simple and can be used in almost every school, especially considering that only smartwatch/band are required. It can be used as a source for data for research works for students researching contests.

Topic: Physical activity effect of human muscle and fat tissue amount.

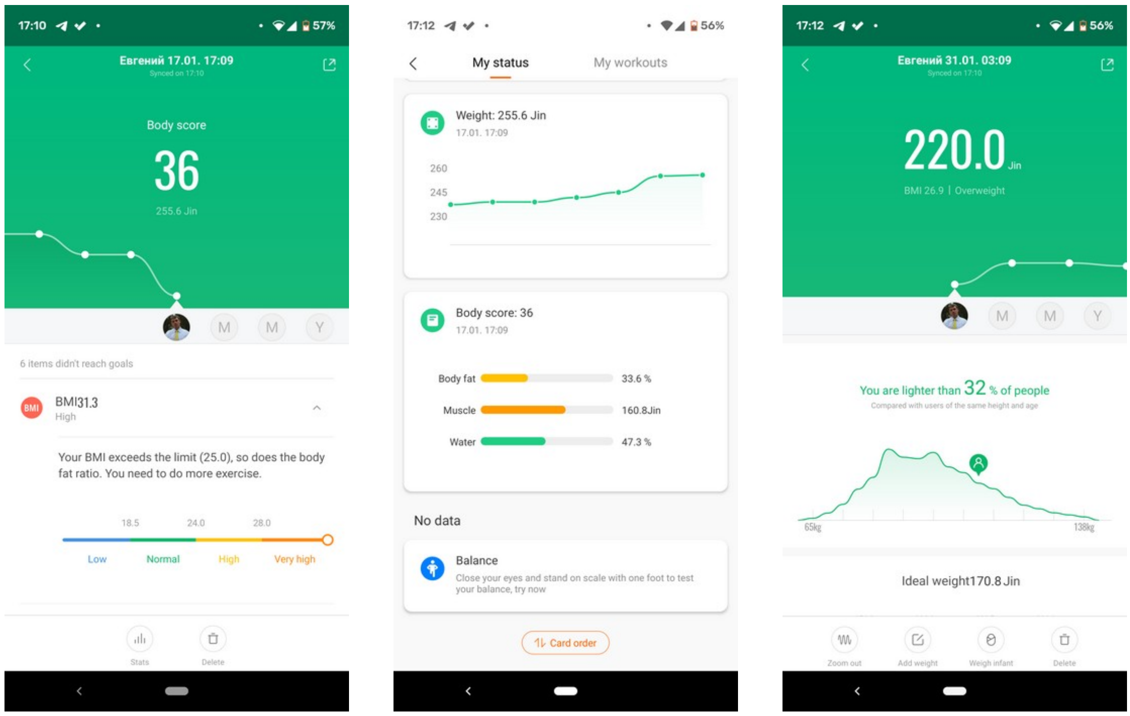
Aim: Demonstrate to students that regular exercise increases the amount of muscle tissue.

Equipment: smart scale.

Experimental procedure: Measure the amount of your muscle tissue using a smart scale. Starting the next day, perform one of the two options:

1. Perform three approaches for 30 squats and three times for ten push-ups. Repeat the exercise cycle four times a week. Leave three days to rest.

(a)

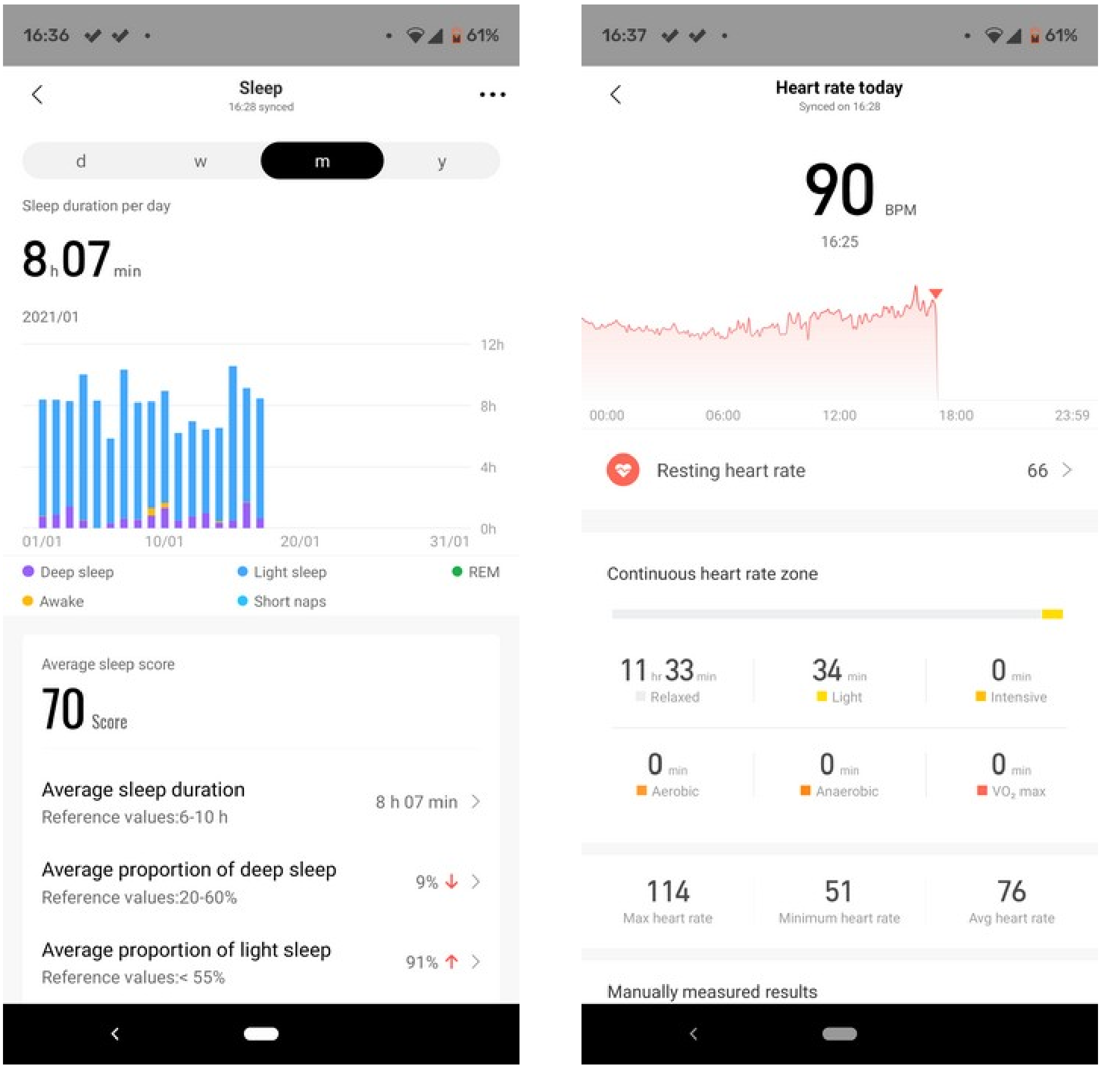


(b) (c) (d)

Figure 7: Screenshot of the method of mathematical modelling of student's nutrition ration (a), dynamic of the automatically body state estimation (b), current state of the body (fats, muscles, water content) (c) and weight dynamic and comparing with other users (d).

2. Make a 2–4 km run every day. Measure your muscle tissue using a smart scale over sixth months. Measure the amount of your muscular tissue using a smart scale every day for sixth months. Capture data with smartwatch/band interface as data or import it into Excel, and at the end of the year analyse the data on your muscle tissue development.

Analyse of data: Analyse the dynamic of the weight changes and its content. Define, the tendencies in changes of fat and muscles tissue amount. Define, changes in time stages (stress and adaptation). Calculate the weight of fats and muscles lost during the research. Try to define as the process of decreasing fats linear, or it has steps. Describe the steps if



(a) (b)

Figure 8: Dynamic of the long and short stages of sleep (a) and dynamic of the heart rate (b).

they were. The method involves performing exercises close to sports, which is why a preliminary medical examination and teacher's supervision are required.

Topic: Influence of fitness zone training on resting heart rate.

Aim: To teach students to individually calculate the maximum heart rate and the number of contractions that correspond to the fitness zone of physical activity, to select a set of exercises, the implementation of which will determine the required heart rate.

Equipment: IoT or smartwatch/band or fitness tracks with heart rate monitoring functions.

Experimental procedure: Students measure heart rate with a smartwatch/band. Then calculate your maximum heart rate according to the formula:

- For the girl $209 - (0.9 \times age)$
- For the boy $214 - (0.8 \times age)$

Then count 70–80% of maximum heart rate. This will be the optimal amount of heart rate during exercise. Students need to choose their own set of exercises, which will require the number of heartbeats controlled by a smartwatch/band. After three months of regular exercise, students measure their resting heart rate again.

Analyse of data: Define the optimal physical activity provides a student's heart rate in the fitness zone. Define the mean physical activity in the group and compare the individual results. Define dependencies of optimal physical activity to sex, weight and age.

When doing work, students learn to use smartwatches/bands and process their data.

5 CONCLUSIONS

The amount of the smart tools increased due to its usability and transcendent performance. In 2022 may be represented up to 1.1 billion of individual smart instruments due to shift from 4G to 5G. That means every seventh person on the Earth will use smart tools. So, firstly the concrete methods, which can be used during educational researches of STEM based process has been introduced.

At the first time, "As is – To be" BPMN method was proposed to evaluate the effect of the proposed method. By using of these methods were proved that using of personal smart tools during STEM education characterizing by enhanced automatization and provide developing of student's thinking, using of graphs, calculation and involving students to conduct of the individual researches.

Training, health-preserving control, ergonomic, mathematical competences, competences in the field of natural sciences, engineering and technology and social competence can be achieved using personal smart tools to provide educational researches.

"Measure of the heart rate before and after physical activity with smartwatches/bands", "Effect of sleep duration on heart rate", "Determination of differences in muscle, fat and bone composition in men and women", "Determination of the level of saturation in suspected COVID-19", "Diet effect on body parameters, especially on the amount of muscle, fat and bone tissue", "The physical activity effect on sleep duration and heart rate", "Physical activity effect of human muscle and fat tissue amount", "Influence of fitness zone training on resting heart rate" methods has been developed and ready to use.

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Analysis and Summarization of the Experience of Developing Adaptive Learning Systems in Higher Education

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Keywords: Model of Adaptive Learning System, Adaptive Learning, Adaptive Learning System, Higher Education, Personification of Learning, Professional Training, Individualization of Learning.

Abstract: The article provides a brief analysis and summarization of the existing experience of developing adaptive learning systems in higher education. Existing models of adaptive learning systems, which are necessary for the educational process in higher education, are analyzed. Conclusions are made as for the requirements for the design and modeling of the author's adaptive system of future specialists' professional training in a blended learning environment. The main ones are requirements for the approaches to modeling, types of adaptation implemented in the system, ways to ensure individualization and personification in the process of both face-to-face learning and learning with the help of information and communication technologies.

1 INTRODUCTION

In terms of socio-economic and evolutionary changes in the society, science and technology modern educational process in higher education requires appropriate changes (Ryabinova, 2009) and modifications of learning strategies. Among promising and relevant technologies in education today there are adaptive learning technologies that help the educational system to adapt to the specific features and needs of a student and are typically controlled by the computational devices, adapting content for different learners' needs and sometimes preferences (Shute and Zapata-Rivera, 2007). With the rapid development of the artificial intelligence in education (Abuselidze and Mamaladze, 2021), adaptive learning system has become the trend of web-based e-learning system (Chen and Zhang, 2008).

Research and implementation of adaptive learning technologies has contributed to the development of the adaptive learning system. Adaptive learning system is a platform for individual learning, which uses different techniques of artificial intelligence to adapt instruction to the learner's individual differences, such as the learning ability, preferences, learning style and learning goal etc. (Chen and Zhang, 2008).

Since the emergence and development of adaptive learning technologies, scientists have proposed various models of adaptive learning systems: KFS (Knowledge Flow Structure), which is based on the concept of knowledge flow (Kurgan, 2013); DCM (Dynamic Content Model), which uses a concept map for the organization and presentation of knowledge (Kristensen et al., 2007); model, designed by Solovov (Solovov, 2010), the main concepts of which are the educational element, content graph and specification of educational elements (de Marcos et al., 2007); CDCGM (Competency-Driven Content Generation Model), which is focused on the availability of all training materials for the electronic training course developer; this materials are stored in the form of educational units related to the competence bank; SHM (Structural-Hierarchical Model), which provides tools for describing the didactic structure of educational units (Silkina and Sokolinsky, 2016). On the other hand, Oxman and Wong (Oxman and Wong, 2014)

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Osadcha, K., Osadchyi, V., Kruglyk, V. and Spirin, O.
Analysis and Summarization of the Experience of Developing Adaptive Learning Systems in Higher Education.
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prove that the use of adaptive learning in higher education has been slower to develop, and challenges that likely contributed to slow adoption remain. It is facilitated by partnerships between publishers and adaptive learning companies. In 2010, Knewton expanded beyond its initial GMAT prep product to partner with large universities to create adaptive remedial math education courses. In 2013 Career Education Corporation partnered with CCKF (international education technology firm) to build 300 adaptive courses using its adaptive learning system RealizeIt. In 2017, the University of Central Florida and Colorado Technical University partnered with RealizeIt to explore how best to use an adaptive learning platform to increase student success (Dziuban et al., 2017).

Despite the development of adaptive technologies, a review of previous research works has shown that a system that combines the capabilities of adaptive technologies, individualization and personification in the conditions of blended learning in a higher educational institution has not been modeled and developed yet. Such a system is needed to improve the training of future professionals, which is becoming more technological, student-centered and variable. In order to develop a new adaptive learning system, it is advisable to analyze and summarize the existing experience of adaptive learning systems development in higher education. This is the aim of our research, oriented for the identification of the requirements for the design and modeling of our own adaptive learning system for future professionals' training in a blended learning environment.

2 METHODS OF THE STUDY

Methods of research:

- methods of specification and systematization of theoretical knowledge were used for the development of the research objectives
- methods of analysis and summarization of psycho-educational, specialized and technical sources on the use of adaptive learning technologies in order to identify the structure and characteristics of existing adaptive learning systems and requirements for our own adaptive system of individualization and personification of future professionals' training in a blended learning environment.

3 RESULTS

3.1 Analysis of Existing Adaptive Systems in Higher Education

Using the search tools of Google Scholar, ERIC, Web of Science and Scopus, we were searching for scientific papers on the development of adaptive learning systems which could be used in higher education. We highlighted those that were publicly available: 60,462 – in ERIC, 92 – in Web of Science, 183 – in Scopus. Of the 2,780,000 articles in Google Scholar, we singled out articles by Russian and Ukrainian authors. We analyzed studies representing the development of adaptive learning systems (platforms) in higher education.

Burdaev (Burdaev, 2006) proposed an adaptive system EOS "KARKAS", which is aimed at training and testing of students of economic specialties. It includes the following components: an output machine to provide training; output machine for adaptive testing; learner error analyzer. This system contains a number of models: 1) a model of learning, characterized by the following parameters: learning objectives; types of errors occurring during the assessment tasks execution; time of the assessment tasks execution; need for assistance while executing a task; 2) models of the learners, characterized by the following parameters: psychological type of students' behavior; level of students' intellectual development; level of readiness for the subject under research; motivation. The adaptability of learning in EOS "KARKAS" is realized in the fact that at each checkpoint a selection of the learning model takes place depending on the level of learner's knowledge. As a result, such parameters as sequence, depth and forms of content presentation are modified.

The structure of Pedagogically Adaptive Learning System based on Learning Styles, designed by Siadaty and Taghiyareh (Siadaty and Taghiyareh, 2007), includes the domain knowledge module, the learner model, the pedagogical module and the interface module (figure 1).

The domain model is a knowledge representation of the materials that the learner has to learn and includes a set of domain concepts such as facts, lessons and problems forming a kind of semantic network. The learner model is a hybrid model, i.e., it consists of a stereotype model (which classifies the learners based on their entry behaviors or characteristics) and an overlay model (which is used to represent users' knowledge of the concepts of the subject domain). The pedagogical module assumes responsibility for making decisions about what will be learned, how it

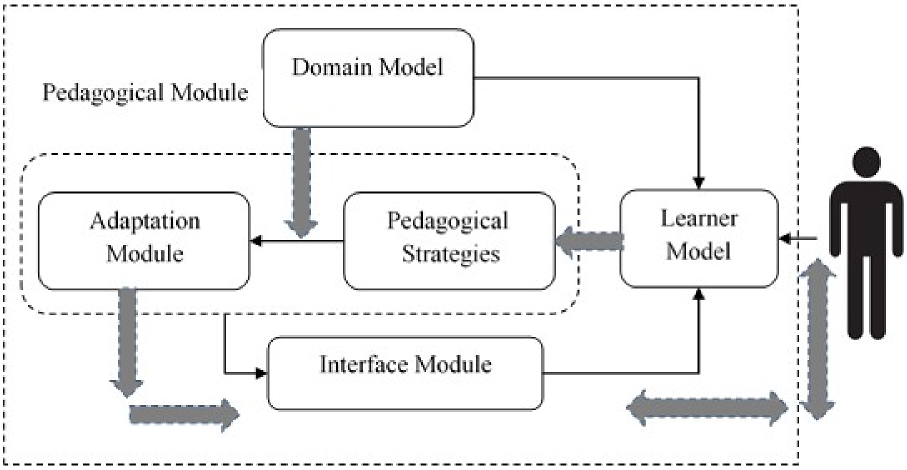

Figure 1: Architecture of the system (Siadaty and Taghiyareh, 2007).

will be learned, when it will be learned. The interface module delivers the personalized contents to the learners and receives their feedback as well.

The adaptive learning system, proposed by Chen and Zhang (Chen and Zhang, 2008), is oriented for learning style and cognitive state. Its architecture is comprised of the media space, domain model, learner model, instruction model, adaptive model and user interface. Media space includes the instructional resources database (all kinds of teaching materials, such as text, picture, audio, video, cartoon, etc.) and instructional resources description models (teaching resources by SCORM standard). Domain Model is the repository of storing and structuring the instructional content in the particular domain, such as a course. Domain Model includes the learning objectives hierarchy and domain ontology. Learner Model is used to provide a foundation for diagnosing the learning process, providing the adaptive learning support for learners. Instruction Model is used to simulate the teacher's teaching strategies; it stores the specific teaching rules. Adaptive model stores the adaptive rules of the system, including the content adaptation rules and adaptive navigation support rules. User Interface provides the interaction function between learners and adaptive learning system.

The adaptive distance learning system, proposed by Gorohovskiy and Troyanovskaya (Gorohovskiy and Troyanovskaya, 2015), includes the following modules: module for collecting data on student's activities (to provide primary data on direct and indirect assessment); module for issuing methodical materials, which directly displays a lecture or practical materials; automatic module for data processing and issuance of material for processing primary evaluation data and appropriate selection of training materials and assessment elements (figure 2). In this composition, it suits the peculiarities of student's perception of educational material.

Red (Red, 2010) described RATOS-AI, an intelligent adaptive system for the development and maintenance of distance learning courses, consisting of the following elements: 1) module for each role of a teacher (teacher-methodologist module, teacher-consultant or tutor module, teacher-designer of training courses module); 2) core IASDL of RASOS-AI; 3) four knowledge bases (subject area, separate academic course, reference model of knowledge, current model of pharmacist's knowledge), database of training protocols, database of electronic publications and database of training scenarios; 4) information system of monitoring of learning; 5) repository of educational elements; 6) training system and assessment system module; 7) systems of communication and access to the single information space of University, as well as the subsystem "Dean's Office".

The adaptive system of distance learning and knowledge assessment EduPRO, presented by Fedoruk (Fedoruk, 2010), includes a model of lecture material structuring, model of adaptive testing and a model of decision-making on transitions between levels of complexity in the adaptive testing system. The system makes it possible to organize the process of individualized learning, allowing teachers to form an individual structure of educational material and identify the moment of students' readiness for the transition to a more complicated level of material.

Information and training system ICT PROFF (Huang and Shiu, 2012) uses modified psychological tests adapted to the computer procedure of interviewing respondents with automatic calculation of the coefficients of personalized models of learning mate-

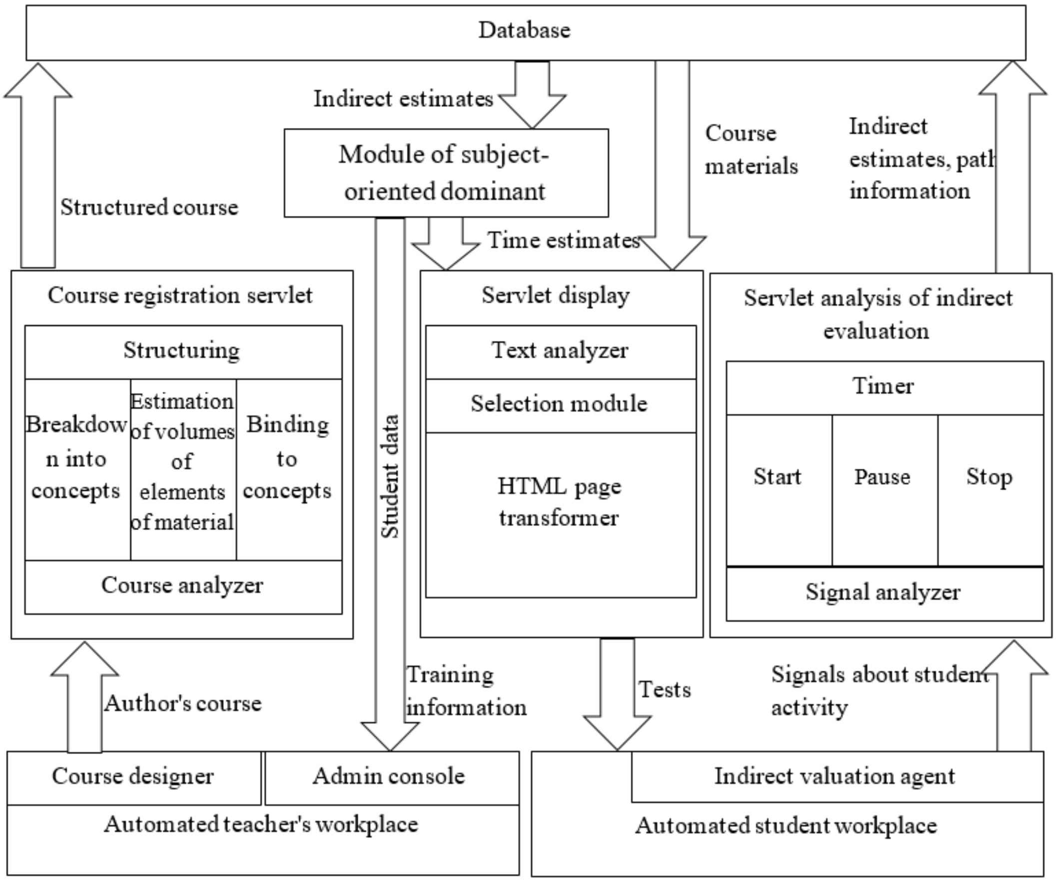

Figure 2: Technological structure of adaptive distance learning system (Gorohovskiy and Troyanovskaya, 2015).

rial and subsequent calculation of external support of the learning process. ICT PROFF system basically uses a modern intelligent CAD software environment MVTU version 3.0, designed for detailed analysis and study of dynamic processes in technical, economic and social systems. The developed adaptive system of personalized professional training of students allows building the predicted trajectories of knowledge mastering for each student that can be used for the formation of homogeneous educational groups.

User-centric adaptive learning system was designed by Huang and Shiu (Huang and Shiu, 2012). It uses sequential pattern mining to construct adaptive learning paths based on users' collective intelligence and employs Item Response Theory (IRT) with collaborative voting approach to estimate learners' abilities for recommending adaptive materials. Such adaptive learning, which is oriented for the user, is comparable to expert-designed learning and learners are more satisfied and learn efficiently. The system architecture is illustrated in figure 3.

Vlasenko (Vlasenko, 2014) has described an adaptive distance learning system in the field of information technology, which is based on the basic components used in existing distance learning systems, namely: blocks (diagnostics of the initial level of knowledge, formulation of learning objectives, design and correction of curriculum, testing, model design, formation of educational elements, correction of model, assessment of achievements); databases (personal test tasks, entry-level test knowledge tasks, test tasks to assess learning outcomes), models (learner model, adaptation model). Adaptation of the system to the learner is carried out on the basis of a model which, in addition to standard parameters, includes such parameters as the degree of learning outcomes achievement, system of learner's advantages, individual curriculum, etc. Adaptation at the stage of planning teaching is carried out by developing a curriculum that, on the one hand, meets learner's needs and preferences and, on the other hand, provides training which is appropriate to the competency model and therefore meets the labor market requirements.

Yasuda et al. (Yasuda et al., 2015) offered adap-

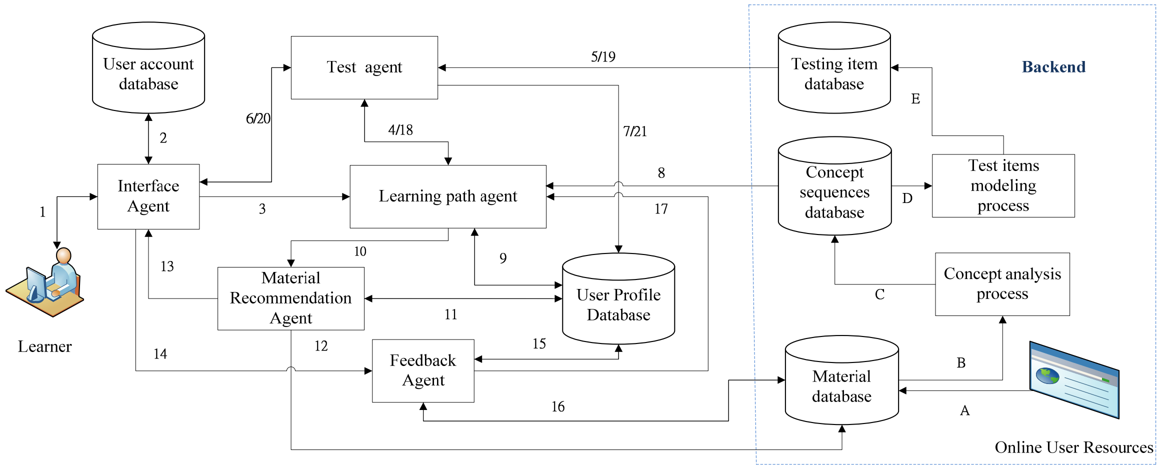

Figure 3: User-centric adaptive learning system architecture and operation procedure (Huang and Shiu, 2012).

tive learning system using a Bayesian network (figure 4). The system has 2 modes: testing mode and learning mode. The testing mode gauges learners' understanding in each course unit using the Expected Value of Network Information (EVINI)-based adaptive testing scheme. In the proposed system, the learning mode assigns each learner drills on course units that the learner is not good at. The Bayesian net framework is used to calculate expected value of network information. The configuration of the proposed system includes such structural elements: the WEB application server that runs HTML5-based drill contents for both modes; Bayesian net server that infers the probability that the learner has understood each of the not-yet-set units, by examining the accuracy of previous answers; the database server that stores learners' logs, which contain each learner's drill answers.

The developers included the following elements into the adaptive information learning system (Fedusenko et al., 2017): a subsystem of learning (subsystem of working with D-graph, subsystem of working with student model), subsystem of knowledge assessment (subsystem of task design, subsystem of assessment), knowledge base and database. Its use allows increasing the efficiency and quality of education by selecting an individual learning path for each student.

To study a foreign language, an adaptive automated system "Arcturus" was developed (Skliarova, 2016). It solves a number of tasks related to the automation of the processes of foreign language competence development. The system has the following features: differentiation of its elements according to the level of complexity; automation of the process of test tasks design with different levels of complexity; multi-criteria methods for the evaluation of education quality; methods for evaluating student's psychophysical characteristics while learning with the help of this system; tools for modeling the process of student's individual path in learning a foreign language; methods for enhancing the quality of optimal control of the individual learning path; tools of control flow statement of educational process of system; development of algorithm of system functioning.

The system, proposed by Shershneva et al. (Shershneva et al., 2018), is aimed at teaching mathematics. This system consists of a subject area module, user model (information about student, which is needed to adapt educational content to his or her individual characteristics and monitor the learning process in the electronic environment), adaptation model (automated navigation system and adaptation of educational content based on learner's individual characteristics), and model of learning outcomes assessment (identification of the level of student's subject competence through the assessment of all its components) (figure 5). The authors of this system state that it is a universal system and it can serve as a basis for the organization of adaptive learning in the electronic environment not only in the field of mathematics but also in other disciplines of educational programs in various fields of training in secondary, higher and extracurriculum education.

According to Toktarova and Fedorova (Toktarova and Fedorova, 2020) in order to train students in mathematics in the information-educational environment it is recommended to introduce such adaptive system which is based on the adaptation of training to students' individual features, management of learning process in the information-educational environment, use of mobile devices for training, and a

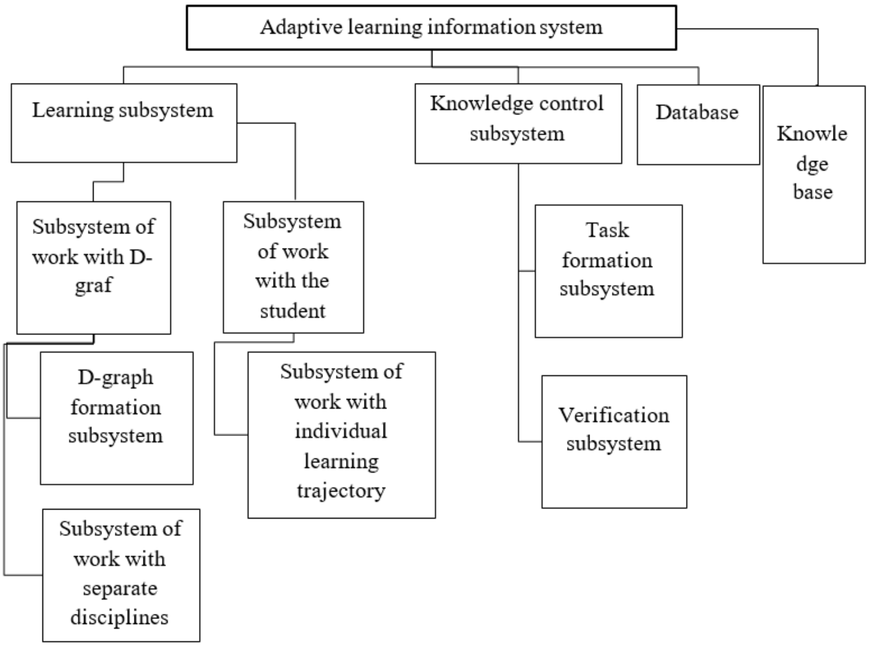

Figure 4: Conceptual model of adaptive information system (Yasuda et al., 2015).

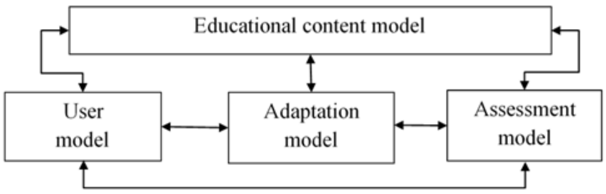

Figure 5: Structural scheme of the adaptive system of web-based teaching (Shershneva et al., 2018).

set of educational-methodological and technological means.

3.2 Identification of Requirements for an Adaptive System of Individualization and Personalization of Future Specialists' Professional Training in a Blended Learning Environment

Based on the analysis of the above mentioned models of adaptive systems, we have identified the following requirements for an adaptive system of individualization and personalization of future specialists' professional training in a blended learning environment. The system should:

1) be based on polyparadigmatic and systematic approaches to its modeling, which involve the use of an open cluster of approaches to learning, their integrated application in a structure of interconnected subsystems;
2) provide the adaptation of educational materials, learning outcomes monitoring, devices (PC, smartphone, tablet computer), and face-to-face classes to the students' individual characteristics;
3) enhance a learner-centered approach in the process of both face-to-face learning and learning with the help of information and communication technologies; in order to implement this system the following should be done: automated study of student's individual features, tutoring and support of student's individual educational program, individualization of learning process, development of student's individual features and his or her new characteristics according to personal educational needs, monitoring and recording of student's individual progress;
4) provide the personalization of the electronic educational environment as well as learning environ-

ment;

5) include both modern educational technologies (interactive methods, intensification, project work and creative learning, etc.) and information and communication technologies (distance learning technologies, analysis and processing of big amount of data) for future specialists' professional training in a higher educational establishment;
6) include subsystems that characterize certain areas of future professionals' training (adaptation, individualization, personalization of training) and reflect the mixed nature of training;
7) be implemented as a working prototype of an adaptive system for different groups of stakeholders and use an adaptive system for individualization and personalization of future professionals' training in a blended learning environment.

Based on the analysis of the existing adaptive technologies (Osadcha et al., 2020) and ICT for individualization (Kruglik and Chorna, 2020) and personification (Osadchyi and Krasheninnik, 2020) of training and in order to implement the requirements for the system, we can conclude that it is appropriate to implement the following learning tools in an adaptive system of individualization and personalization of future specialists' professional training in the context of blended learning: Moodle platform and plug-ins for adaptive learning, capabilities and properties of Moodle for the implementation of individualization of learning (competence module and progress block, tools for imposing necessary restrictions on learning elements, means of multicriteria assessment, tools for multivariate presentation of educational information, etc.), a set of information and communication technologies and modern technical means of learning to ensure the personification of learning. This will allow us to design an adaptive system of individualization and personalization of future professionals' professional training in a blended learning environment, which will consequently promote the impact of distance technologies on the improvement and intensification of learning in higher educational institutions.

4 CONCLUSIONS

Analysis of adaptive learning systems and their models showed that these solutions have a narrow applied character (teaching mathematics, languages or teaching students of a particular specialty). They do not contain all necessary elements for educational process organization or do not have the structural elements and functional features required by teachers and students in the modern educational process. We have also generalized the requirements for the adaptive system of individualization and personalization of future specialists' professional training in the conditions of blended learning. These requirements are as follows: system modeling has to be done according to polyparadigmatic and systematic approaches; it should take into account the tasks of adaptation, individualization and personalization of future professionals' training; the system should be structured in accordance with the functional purpose of its elements; the system should be implemented in the form of a working prototype based on the Moodle platform tools. The adaptive learning system should be easy to use in the process of learning, have an intuitive interface and appropriate structure, as well as the tools which are necessary for future professionals' effective training.

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Psychological Security in the Conditions of using Information and Communication Technologies

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Keywords: Psychological Security, Traditional Learning, Distance Learning, Information and Communication Technologies, Participants of the Educational Process, Teachers of Higher Education Institutions.

Abstract: The article substantiates the relevance and expediency of the study of psychological security of the personality in the conditions of using information and communication technologies (ICT). The purpose of the research is an empirical study of the psychological safety of teachers of higher education institutions in the conditions of using information and communication technologies. The influence of traditional (classroom, offline) and distance (online) types of training on the sense of security of teachers of higher education institutions in the conditions of using ICT is analyzed. Today's realities, in particular the global pandemic caused by the spread of COVID-19 virus infection, have significantly accelerated the introduction and implementation of distance learning and significantly expanded the range of participants in the educational process. Therefore, it has been suggested that teachers of higher education institutions assess traditional (classroom, offline) learning as safer than distance (online). The results of an empirical study of psychological safety in the conditions of using ICT by teachers of higher education institutions are presented. A comparative analysis of the sense of security by teachers of higher education institutions in the context of traditional (classroom, offline) and distance (online) learning was performed. Associations of distance and traditional learning have been found to have significant differences. Groups of concepts in which associations of respondents are invested ("negative", "positive", "neutral") are defined. It is analyzed that associations for the phrase "distance learning", "full-time learning" are located on three semantic "fields": actions, states and characteristics of the referent of the word-stimulus; actions, states and characteristics of other subjects; feelings and emotions. Differences in the perception of distance and traditional learning by teachers depending on the time they spend on online learning were identified. It is determined that the level of psychological security is equally mediocre in both traditional and distance learning. Statistically significant relationships were found between the sense of security in online and offline learning.

1 INTRODUCTION

Scientific and technological progress is rapidly gaining momentum and covers all areas of personality's life activity. Today, no sphere of public life, including educational, is effective without the involvement and implementation of scientific and technical means. The involvement of developments of scientific and technological progress in the educational process is particularly rapid now – in a global pandemic caused by the spread of viral infection COVID-19 (Pomytkin, 2020; Pomytkin and Pomytkina, 2020; Tkachuk et al., 2021). One of the ways to implement information and communication technologies is the introduction of distance learning (Syvyi et al., 2020).

Distance learning is defined as an individualized process of acquiring knowledge, skills, abilities and ways of human cognitive activity, which occurs mainly through the indirect interaction of distant participants of the educational process in a specialized environment that operates on the basis of psychological, pedagogical, information and communication technologies (zakon.rada.gov.ua, 2013). We

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can say that distance learning is implemented using a set of modern technologies that ensure the process of providing and receiving information in an interactive mode with the use of information and communication technologies by all participants in the educational process.

It is obvious that the main role in the implementation of distance (online) education, as well as, in fact, traditional (classroom, offline), is played by information and communication technologies. The latter, in turn, are defined as technologies for creating, accumulating, storing and accessing electronic resources of educational programs and training materials, providing and supporting the educational process using specialized software and means of information and communication, including the Internet (zakon.rada.gov.ua, 2013). It is the Internet that reveals the possibilities of virtual connection and communications.

2 LITERATURE REVIEW

Almarashdeh (Almarashdeh, 2016), Barvinskaya (Barvinskaya, 2020), Bobyliev and Vihrova (Bobyliev and Vihrova, 2021), Bykov et al. (Bykov et al., 2001), Chernyshov (Chernyshov, 2021), Dos Santos (Dos Santos, 2020), Duell (Duell, 2008), Finley (Finley, 2012), Gajek (Gajek, 2018), Giest (Giest, 2004), Giest (Giest, 2008), Karadeniz (Karadeniz, 2009), Kukharenko and Oleinik (Kukharenko and Oleinik, 2019), McGinnis (McGinnis, 2010), Mills (Mills, 1997), Rourke and Anderson (Rourke and Anderson, 2002), Seguin (Seguin, 2021), Sezer (Sezer, 2016), Teplow (Teplow, 1996), Traxler (Traxler, 2018), Weety (Weety, 1998), Wells (Wells, 2021) conducted scientific research in the direction of theoretical, empirical and social aspects of the introduction of distance learning, analyzed the problems of the introduction of distance learning and the features of the involvement of information and communication technologies.

Empirical research on educational technologies used in distance learning has become widely known. In particular, Anderson and Rivera-Vargas (Anderson and Rivera-Vargas, 2020) identified and critically substantiated the main dimensions of using digital technologies in distance education, which led to significant changes, namely: reducing the quality of education; restriction of application of new knowledge development methods; copyright infringement; excessive idealization of information and communication technologies; violation of private information due to the widespread use of social media in distance education (Anderson and Rivera-Vargas, 2020).

At the same time, Anderson (Anderson, 2019) notes that social media, as a tool of information and communication technologies, is a major component of commercial, entertainment and, of course, educational activities. Education has a unique opportunity to control and improve their own practices through the dissemination of social media, which are effective for all participants of the educational process. In particular, teachers, educators and mentors have additional opportunities to communicate with students. An important aspect of this connection is the control and intervention in the learning process in order to increase the effectiveness of both teaching and learning. New ways of finding, receiving and exchanging educational information are becoming available for learners (pupils, students) (Anderson, 2019).

Sancho-Gil et al. (Sancho-Gil et al., 2020), Pomytkin et al. (Pomytkin et al., 2020) point out that the development of ICT has caused excessive concern about its ability to solve educational problems and improve the quality of learning. Such a situation requires the development and implementation of new digital technologies in education for effective digital inclusion in order to expand public knowledge about the possibilities of using information technology in the educational environment.

The urgent need for the implementation and implementation of distance learning creates excessive excitement and uncertainty among all participants of the educational process. Thus, Anderson (Anderson, 2019) notes that the main difference between distance learning and traditional is the exhaustion of its participants.

Distance learning, accompanied by the intensive use of information and communication technology tools, in particular, the inclusion in the digital information environment of participants of the educational process, leads to a deterioration in psychological well-being and information stress. The latter, in turn, is associated with the long-term use of information and communication technologies, in particular, the Internet (Kislyakov, 2020).

Social networks, watching news, consuming information, etc. lead to increased information stress and reduce the level of psychological security of the personality. The problem of information and psychological security is related to such psychological aspects as the perception, preservation, processing and use by participants in the educational process of a certain information array (Krasnyanskaya and Tylets, 2019).

The concept of psychological security can be described as a state of psychological safety and the ability of the personality to withstand unpleasant external and internal influences. Psychological security is an important factor of interpersonal interaction (Edmondson, 1999, 2004). The latter is significantly reduced in terms of distance learning, which is confirmed by scientific research. A study (Hu et al., 2018) reported that the lower the level of psychological security of the personality, the higher the level of distance interaction. The dependence of a sense of psychological security in terms of distance or traditional learning is evidenced by the results of several studies. In particular, the relationship between psychological security and social networks is revealed (Soares and Lopes, 2014), which is one of the main tools of interaction between participants in the educational process in distance learning.

Given the significant amount of research on the study of psychological security and information and communication technologies, the aspect of psychological safety of teachers of higher education institutions in the conditions of using ICT remains insufficiently studied.

The *purpose* of the research is an empirical study of the psychological safety of teachers of higher education institutions in the conditions of using information and communication technologies. In our study, we made assumptions that the teachers of higher education institutions evaluate traditional (classroom, offline) learning safer than distance (online) learning.

3 RESEARCH METHODS

The study of psychological safety in the use of ICT was implemented during the autumn semester of 2020. Teachers of higher education institutions (N = 59) took part in the study, including 48 women (81%) and 11 men (11%). The age of respondents varies between 25–75 years, the largest share are teachers aged 25–44 years (75%), 11 teachers aged 45–60 years (19%) and 4 teachers aged 61–75 years (7%).

To study the features of psychological safety in traditional (classroom, offline) and distance (implemented as a measure to combat the spread of coronavirus disease (COVID-19)) forms of studying was developed and implemented author's questionnaire "Psychological security in conditions of using ICT". Its validity and reliability were ensured by using the method of independent expert evaluations. The questionnaire contained three components that assess both the conditions of distance learning and its psychological component: determining the intensity of involvement in distance learning (time spent), the study of associations on different forms of learning and the subjective level of psychological security (on a five-point scale) during distance and full-time forms of education.

The method of frames (schemes) was used for qualitative and quantitative analysis of associations. This method allows you to group associations by certain descriptive characteristics that can be applied to abstract concepts: 1) actions, states and characteristics of the word-stimulus, 2) actions, states, characteristics of other subjects, 3) feelings and emotions (Mironova, 2011) and the method of expert assessments. Methods of mathematical statistics were used for statistical processing of the obtained quantitative data (descriptive statistics, comparison of dependent samples (Student's t-criterion), Spearman's rank correlation analysis). Automated data processing was performed using the IBM SPSS Statistics 26 and the ArcGIS software packages.

4 RESULTS AND DISCUSSIONS

According to the results of empirical research, the frequency hierarchy of associations for the phrases "distance learning" and "full-time learning" was revealed. Analysis of the results shows that teachers of higher education institutions associate the phrase "distance learning" primarily with ICT: "computer" (6%), "Internet" (6%), "Moodle, Classroom, Viber" (4%); with an evaluative attitude: "fast" (4%), "imperfect" (4%), also significant is the affective component, which has a negative emotional color: "stress" (4%).

The hierarchy of associations for the phrase "full-time education" differs significantly from the previous one. The main associations are aimed at interaction, and interpersonal connection – "communication" (17%); identification of specific characteristics of direct interaction – "live communication" (13%), "communication" (6%), "knowledge" (6%).

Qualitative analysis of reactions (associations) based on the method of frames (Mironova, 2011) allowed to make their qualitative characteristics.

Field 1. Actions, states and characteristics of the word-stimulus. The phrase-stimulus "distance learning" is expressed through actions, states and characteristics that describe the effectiveness of distance learning, its impact on the physical and mental state of the respondent: for example, "inappropriate", "undesirable", "low efficiency", "exhausting", "long", "simple ", etc. The characteristics of the phrase-stimulus "full-time learning" mostly reflect its focus on the communicative process, such as "communication", "live communication", "energy of live communication", "simple", "fast".

Field 2. Actions, states, characteristics of other subjects. In the associative chain of the phrase-stimulus "distance learning", the interiorization is traced: the "other subject" is the respondent (for example, "insomnia", "control", "day mode", "sleep"). At the same time, in the associative chain for the phrase-stimulus "full-time study", respectively - exteriorization (for example, "students", "I know where the child is", "friends", "noise", "fun", "long time to get to", "waste of time").

Field 3. Feelings and emotions. The associative chain of the phrase-stimulus "distance learning" is characterized by the narrowness and uniformity of emotional characteristics, such as "sadness", "worrying", and so on. The associative chain of the phrase-stimulus "full-time learning" is dominated by concepts that characterize feelings and emotions. They differ in variety and bright emotional color, such as "fun", "contact", "attentive", "emotions".

With the help of expert assessments, the associations were grouped into three groups: "negative", "positive" and "neutral". Negative associations include those that have an expressed negative evaluation attitude or emotional coloring, such as "sadness", "horror", "forced step", "low efficiency", and so on. Neutral associations include those that reflect events, objects, phenomena, objective reality, such as the "Internet", "audience", "Zoom", etc. Positive associations include those that have a positive emotional color or evaluation, such as "fun", "live communication", "good feedback", and so on. By assigning a numerical value to each group of associations ("0" = "negative", "1" = "neutral", "2" = "positive") and using methods of statistical data processing, it was found that associations of teachers of higher education institutions regarding distance and traditional education differ significantly ($t = -4.801, p \leq 0.012$) (table 1).

It should be noted that in each of the three fields, respondents focused on the concept of time spent on distance and full-time study and their characteristics, such as "more time for themselves", "fast", "slow", "waste of time", "all day", "round-the-clock access", "work after work", "no waste of time", etc. Peculiarities of the perception of distance learning by employees of higher education institutions depending on how much time they spent on average during the working week on distance learning are presented in table 2.

The most negative perception of distance learning is perceived by respondents who have been involved in it for less than 6 hours (58.3%). Respondents who spend more than 18 hours a week on distance learning also rate it rather negatively. The smallest number (32.0%) of negative associations regarding distance learning have respondents who are involved in it for 6–18 hours. It should be noted that the more respondents were involved in distance learning, the less positive (4.5%) and more neutral (50.0%) associations they have with it.

Those who spend an average of 6 to 18 hours a week on distance learning tend to describe it most positively.

The results of the analysis of associations for the phrase-stimulus "full-time learning" are fundamentally different from the previous ones (table 3). Most positive associations (40.9%) regarding full-time education occur in teachers who spend the most time (more than 18 hours) on distance learning, and the least – in those who worked distantly the least (6 hours per week). The vast majority (61%) of respondents generally have a neutral perception of traditional (classroom, offline) learning. It is worth noting much lower rates of negative associations with the phrase-stimulus "full-time learning", compared with distance (respectively, 3.4% and 42.4%).

For a more detailed interpretation of the peculiarities of the perception of distance and full-time learning, the subjective level of psychological security feeling of teachers of higher education institutions during the implementation of both forms of education was determined (table 4). In general, respondents rate their level of psychological security as equally mediocre in distance and full-time learning ($\bar{x} = 2.808$ and $\bar{x} = 2.900$, respectively).

However, we observe contradictions between the emotional perception of online/offline learning and the assessment of their own psychological security in their implementation depending on the time of using ICT. Thus, full-time learning is assessed as the most dangerous ($\bar{x} = 3.307$) by teachers who are most positive about it, and who spend more than 18 hours a week on distance learning. The least dangerous ($\bar{x} = 2.423$) full-time learning is for teachers who are involved in distance learning for less than 6 hours. The most dangerous ($\bar{x} = 3.305$) feel in the online environment those who spend from 6 to 18 hours on it.

To find significant differences between the indicators of experiencing a sense of security in the implementation of online/offline learning by teachers of higher education institutions we used calculations of the Student's t-criterion (table 5). No statistically significant differences were found, but some trends were indicated: teachers who are involved in distance learning for less than 6 hours tend to perceive the online environment as safer ($t = 1.442, p \leq 0.175$), those who work from 6 to 18 hours, on the contrary, as more dangerous ($t = -1.51, p \leq 0.144$). Those

Table 1: Differences in associations of employees of higher education institutions about full-time and distance learning.

Paired Samples Test								
Distance / full time	**Paired Differences**					**t**	**df**	**Sig. 2-tailed**
	Mean	**Std. Deviation**	**Std. Error Mean**	**95% Confidence Interval of the Difference**				
				Lower	**Upper**			
	-.593	.949	.123	-.840	-.345	-4.801	58	.012

Table 2: Emotional perception of distance learning by teachers with different times of using ICT.

Crosstabulation			**Associations to the phrase-stimulus "distance learning"**			**Total**
			Negative	**Neutral**	**Positive**	
Term of online study (hours)	Less than 6	Count	7	3	2	12
		% within	58.3	25.0	16.7	100.0
	6-18	Count	8	11	6	25
		% within	32.0	44.0	24.0	100.0
	More than 18	Count	10	11	1	22
		% within	45.5	50.0	4.5	100.0
Total		Count	25	25	9	59
		% within	42.4	42.4	15.3	100.0

Table 3: Emotional perception of full-time learning by teachers with different time of using ICT.

Crosstabulation			**Associations to the phrase-stimulus "full-time learning"**			**Total**
			Negative	**Neutral**	**Positive**	
Term of online study (hours)	Less than 6	Count	1	7	4	12
		% within	8.3	58.3	33.3	100.0
	6-18	Count	1	16	8	25
		% within	4.0	64.0	32.0	100.0
	More than 18	Count	0	13	9	22
		% within	0.0	59.1	40.9	100.0
Total		Count	2	36	21	59
		% within	3.4	61.0	35.6	100.0

who spent more than 18 hours distantly mediocrely assessed their own safety both offline and online (t=$-0.731, p \leq 0.473$).

Spearman's correlation analysis was used for a more detailed interpretation (table 6). It was found that there is a statistically significant relationship between indicators of psychological safety in distance and offline learning for both respondents of the general sample ($r = 0.358$, $\rho \leq 0.001$) and teachers who are involved distantly for 6-18 hours ($r = 0.528, \rho \leq 0.001$). We do not observe such correlations in respondents who are engaged in online learning for a small or extremely large amount of time.

As the result of the study it was determined that the feeling of psychological security and the perception of teachers of higher education institutions about distance and traditional learning have certain specific characteristics.

5 CONCLUSIONS

1. Psychological security is defined as a state of psychological protection from external and internal influences. In the conditions of distance learning the feeling of psychological safety of its participants decreases, in comparison with the conditions of traditional (classroom) learning.
2. There are differences in the perception of distance and traditional (full-time) learning among teachers of higher education institutions. Associations for the phrase "distance learning", "full-time learning" are located in three semantic "fields": teachers of higher education institutions associate distance learning with ICT and with feelings and emotions, full-time learning is associated with communication and interaction with others. There is a significant difference between distance and traditional learning associations: distance learn-

Table 4: Level of psychological safety of teachers of higher education institutions ($\bar{x}$).

Term of online learning (hours)	Online (distance) learning	Offline (full-time) learning
Less than 6	2.820	3.307
6-18	3.305	2.694
More than 18	2.576	2.423
Total	2.900	2.808

Table 5: The sense of security features of higher education institutions teachers with different time of using ICT in the conditions of online/offline learning.

Paired Samples Test								
Term of online training (hours)	Paired Differences					t	df	Sig. 2-tailed
	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
				Lower	Upper			
Total	-.084	1.734	.225	-.536	.367	-.375	58	.709
More than 18	-.272	1.750	.373	-1.048	.503	-.731	21	.473
6-18	-.416	1.348	.275	-.986	.152	-1.51	23	.144
Less than 6	.846	2.115	.586	-.432	2.124	1.442	12	.175

Table 6: Relationships between psychological safety indicators in online/offline learning.

Sample/term of online training (hours)			Offline/Online
Spearman's rho	Total sample	Correlation Coefficient	.358**
		Sig. (2-tailed)	.005
		N	59
	More than 18	Correlation Coefficient	.241
		Sig. (2-tailed)	.280
		N	22
	6-18	Correlation Coefficient	.528**
		Sig. (2-tailed)	.008
		N	24
	Less than 6	Correlation Coefficient	.327
		Sig. (2-tailed)	.276
		N	13

** Correlation is significant at the 0.01 level (2-tailed).

ing is perceived more negatively than full-time learning.

3. There is a statistically significant relationship between the feeling of psychological security of respondents in distance learning and the feeling of psychological security in offline learning. The subjective level of feeling of psychological security has average indicators, both in terms of distance and full-time learning. Teachers who spend a lot of time online tend to perceive more dangerous full-time learning. The least dangerous are those who are involved in distance learning for a short time. The most dangerous in the online environment feel those who spent on it an average of 6 to 18 hours.

4. Contradictions between the emotional perception of online/offline learning and the assessment of the level of their own psychological security in their implementation depending on the time of using ICT were defined.

The research hypothesis was partially proved. We see *prospects for further research* in the study of the features of psychological security of all participants in the educational process in a wide sample.

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Media Education Technology at Preschool Educational Institutions

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Keywords: Media Education, Media Educational Technology, Forming Media Literacy of Children of the Senior Preschool Age, Media Educational Tale.

Abstract: The article substantiates the media educational technology at preschool educational institutions, in which diagnostic-target, integration and analytical stages are distinguished. The problems in media education implementation at preschool establishments have been identified and the prospects for their solving have been determined. The psychological factors of forming media literacy of children of the senior preschool age have been highlighted. Diagnostic toolkit has been developed and indicators of high, sufficient and low levels of media literacy of preschoolers have been determined. The experience of conducting media educational classes "Grains of media education", the use of media educational tales in working with children have been highlighted. The expediency of media education for kindergarten teachers of preschool educational institutions of Ukraine, formation their motivation for media educational activities with children has been proved. The effectiveness of implementing the media education technology at preschool educational institutions has been confirmed on the basis of positive dynamics of levels of preschoolers' media literacy formation.

1 INTRODUCTION

1.1 Problem Statement

Media threats as manipulations of consciousness, fake messages, dangerous acquaintances, the emergence of dependence on new media, provoking aggression through the media, cruelty, violence, etc. are increasing in the modern Ukrainian society. In such conditions, media education is becoming increasingly relevant, primarily for children, since the age of a child is constantly decreasing when child first contacts the mass media. It is necessary to begin to form media literacy as early as preschool age. There are several reasons for this.

Back in 2016, Ukraine adopted the Concept for the Introduction of Media Education in Ukraine (new edition) (ms.detector.media, 2016), which focuses on preschool media education. In January 2021, a new Basic Component of Preschool Education was adopted, in which critical thinking is defined as a cross-cutting skill of preschoolers (MON, 2021). Critical thinking is often equated with media education (Savchenko et al., 2020). Thus, the need to form media literacy of preschoolers is provided by the new State Standard of Preschool Education. However, media education in preschool education is not limited to

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critical thinking. There are more than ten of them in the Catalogs of Media Competences, and they are formed during several types of preschool activities, primarily by educational lines: "Child's personality", "Child's game", "Child in society", "Child's speech", "Child in the world of Art" (MON, 2021; edukacjamedialna.edu.pl, 2014).

Another reason for early media education is that media literacy in preschool is not perceived as a subject, but as a way of life. Later, teenagers have to be re-educated, changing skills and style of behavior in the media environment. It is much more difficult to do that than to organize properly media education from the very beginning.

Given the relevance of media education in the modern society, the Ministry of Education and Science of Ukraine approved an all-Ukrainian experiment on media education for 2017–2022, which involves 153 educational institutions, not only schools, gymnasiums, lyceums, regional institutes of postgraduate education, but also preschool educational institutions (Dorosh, 2017). However, the question concerning the format of the media education implementation remains controversial, as well as whether preschool age is sensitive to the formation of critical thinking. The creation of teaching and methodological support for media education in preschool is a problem. There are few such publications. Among the first there is primarily "Media literacy and critical thinking in the preschool education" (Volosheniuk et al., 2020).

Despite the fact that preschoolers learn about the world, moral values in play and fairy tales, media educational fairy tale is an innovative media product that is insufficiently known or unknown to preschoolers, kindergarten teachers and parents.

1.2 Literature Review

The influence of the mass media on the development of a child is reflected in (Chorna, 2007; Danyliak, 2017; Tereshchuk et al., 2019; Waters et al., 2016). Scientists focus on the insufficient use of media potential, print media in particular, for the upbringing of children; on the necessity to eliminate the low-end media products.

The issues of the preschoolers' media education are investigated in (Ashytok, 2017; Brzyszcz, 2018; Drzewiecki, 2013; Kachura, 2017; Kondratenko, 2013; Krutiy, 2013; Oliinyk, 2013; Polievikova, 2013; Semeniako, 2016; Sotska, 2013; Šupšáková, 2016). The scientists pointed to the positive functions of the modern media in preschool education: didactic, educational, diagnostic, entertaining, etc. At the same time, they focus on the threats of the modern media to a child and the relevance of media education precisely in preschool, particularly in this context, Kachura (Kachura, 2017) notes: "The average child is already from two years under the influence of the information flow coming from the TV, at the age of three a child shows fairly stable preferences in the choice of cartoons, and to five years, begins to master computer skills. These resources carry so much information that it is difficult to master even for an adult, what to say then about a child. The key to the formation of a person capable of active and safe functioning in the modern media space is media education" (Kachura, 2017).

However, in the works of these scholars forms, methods of media education are not reflected as components of the system of media education. Media educational activities were researched comprehensively by Yankovych et al. (Yankovych et al., 2019), who substantiated the technology of formation of media literacy of older preschool children. However, not all issues have been resolved. The need for a media that combines traditional and innovative approaches to education remains relevant.

The problem of the low level of parents and kindergarten teachers' media literacy, who have to help children to become literate, remains in preschool educational institution. It is obvious that it is impossible to form competence in a child, if you do not possess it yourself. Parents often do not know what media, media education, media literacy are and they associate them with the mass media – radio, television, the Internet. Kindergarten teachers also feel the need to improve their own media culture. In Ukraine, methodological materials for the formation of children's media literacy have only just begun to appear (Volosheniuk et al., 2020). Such developments for a decade are intensively created abroad, in Poland in particular, where the "Media Education" (Edukacja Medialna) web-site operates, with scripts, exercises and additional information for conducting classes in preschools, schools, houses of culture and libraries (edukacjamedialna.edu.pl, 2021).

The materials are elaborated in accordance with the Catalogue of Media and Information Competences defined within the framework of the "Digital Future" project. In addition, other interesting developments for conducting workshops, media education classes for preschoolers and their parents were created (edukacjamedialna.edu.pl, 2014). The systematic work on creating such resources has only begun in Ukraine.

The need for an innovative media product, which would be used with interest by parents with children and thus increase the level of media literacy, was identified.

The relevance of the problem of implementing media education at preschool institutions, the need to perform tasks aimed at the formation of media literacy of children arising from the Basic component of preschool education (MON, 2021), the need for innovative, interesting to children and adults, media products, the need to resolve these controversies led to the definition of the purpose of the study: to prove and experimentally test the media educational technology at preschool educational institutions of Ukraine.

The *object* of the research is institutions of preschool education of Ukraine; the *subject* is the media education of preschoolers (age 5–6).

1.3 Material and Methods

Theoretical and empirical methods were used to realize the purpose of the study.

Among the theoretical ones, primarily are such as functional and structural, interpretive and analytical, comparative analysis of literary and informational sources, through which the investigated problem was studied, forms, methods, means of realization of media education and formation of children's media literacy in Ukrainian pedagogy were revealed. An interview method was used in order to determine modern problems and ways to solve them in a preschool educational institution in relation to the implementation of media education. During the research, the specialists of the Academy of Ukrainian Press (founded in 2001, one of its tasks is the promotion of media education in Ukraine) were interviewed: Oksana V. Volosheniuk – a manager of media education programs of AUP; Yuliia O. Huza – an editor of the "Media Education and Media Literacy" site.

One of the leading methods of the research is modelling – to develop a model of the media educational technology at preschool educational institutions of Ukraine.

In the process of scientific research, empirical methods were used: testing, observation, interviews, experts' assessments, questionnaires, polls to measure the level of media literacy of the experiment participants, as well as pedagogical experiment to verify the efficiency of the media educational technology at preschool educational institutions of Ukraine.

Scientific research was carried out at preschool educational institutions and educational complexes of Ukraine (Kyiv, Ternopil, Khmelnytskyi city and region, Kherson, Mukachevo).

2 RESULTS

2.1 The Peculiarities of the Implementation of Media Education in the Preschool Educational Institution

A comprehensive study on the formation of media literacy of older preschoolers involves the definition of "preschool media education". Often, the very different interpretation of the concepts leads to differences among kindergarten teachers, teachers regarding the forms and methods of media education.

In our opinion, preschool media education is a part of the educational process characterized by a three-component structure (education about media, education through media and for media) that is implemented through the partnership of kindergarten teachers, parents and children, involves the formation of critical, conscious, responsible perception of information to all members in the partnership (Yankovych et al., 2019).

Surely, preschool media education has its own characteristics and is fundamentally different from media education of a student or an adult. This difference lies in the specificity of mental activity, thinking, insufficiency of life experience in preschooler. It is characteristic for a preschooler to thoughtlessly absorb information, which is transmitted from TV screens, computer monitors, radio receivers. Immersing into the informational and virtual world, a child is often not even thinking about the content of what child sees and hears, if they are not prepared for the critical, conscious, responsible perception of information. However, such abilities are difficult to form. There are factors that become an obstacle, but there are those that are favorable.

Thus, the problems will be highlighted at the beginning.

1. According to the periodization of the intellectual development of children by Piaget (Piaget, 1977), a child aged 5–6 years (2–7 years old period) is at the stage of preoperative representations, during which intuitive, visual-effective and visual-imagery thinking develops. Psychologists say that "thinking specifically, preschoolers tend to literally understand a lot. Therefore, they often misunderstand the words used in abstract and figurative meanings" (Brailko, 2010, p. 15). Since preschoolers are characterized by weak abilities to perform abstract mental operations, their thoughts often turn out to be very naive and unrealistic. Therefore, media literacy formation is problem-

atic.

2. Children have limited life experience, they are easily exposed to, and therefore do not realize when it is worth checking information and whether it is true. The main criterion still remains: "familiar-strange" (one can believe a familiar person); authoritative and non-authoritative (parents and kindergarten teachers are authoritative, peers, and often somewhat younger or elder brothers and sisters are non-authoritative). To find errors in the media is an unreal task for an average child to perform.
3. Media education involves its implementation through the media (including TV and computer). At the same time, a child should spend little time at the TV, especially computer (MON, 2021).

At the same time, the potential of preschool age for the formation of media literacy should not be underestimated. In this context, the work of Brailko (Brailko, 2010) are of great interest, who found out that cognitive activity and constant cognitive interest as the foundation of future educational motivation in preschool age (5–6 years) develop. All mental operations actively develop in children.

Liubchenko (Liubchenko, 2014) shows that when children are taught with a kind of purpose (even for a short period of time), the mental process changes very quickly. If 5–6-year-old preschoolers are taught to observe and draw conclusions (for example, to differentiate which things float and which sink, under which conditions leaves appear earlier on the cut brunches of poplars, to compare the shape of a tool with the conditions of its use), significant changes in their mental development occur.

Children learn to search for and identify the most peculiar features of things and phenomena, to find significant dependencies, relationships between them, and thus logical forms of thinking develop rapidly in children (Liubchenko, 2014, pp. 213–214).

The criticality of mind is characteristic for older preschoolers, that lies in the ability to objectively evaluate their own and others' opinions, to thoroughly prove and comprehensively check all the hypotheses put forward. Children who have developed this feature tend to check everything thoroughly before doing anything, and if one opinion does not pass the test, they reject it without hesitation and look for a new, more correct, one (Brailko, 2010, p. 10).

Studying the work of psychologists on the development of mental activity of preschoolers indicates that the formation of critical thinking can only be started in preschool institution, and it is necessary to continue this work at school age. At the same time, it is necessary to implement the pedagogy of partnership (children will not become media literate without the help of parents and kindergarten teachers).

It is advisable to take into account the role of fairy tales in shaping the personality of the preschooler. But for the formation of children's media literacy it is necessary to use it in the combination with cognitive activities.

2.2 Media Educational Tale as a Means of Forming Media Literacy of Preschool Children

A media educational tale is an effective component of the educational and methodological complex "Seeds of media education". In preschool age, play is a leading type of children's activities, and a fairy tale is one of the most effective means of development. We consider a special kind of a fairy tale – media educational tale, which gradually turns into dramatic games: small dramatic actions, where everyone plays the role of a certain hero, are played out by the plot of the fairy tale. But special feature of the media educational tale is not only in this. We have noticed that children love those fairy tales, in which they act themselves as heroes. And that is why in our fairy tales a kindergarten group acts as the hero of the fairy tale.

We have created media educational tales in the following directions: definition of basic terms (what is media), search for information, differentiation of truth and falsehood, safe use of media, communication in media, moral, economic, legal aspects of media (copyright).

For example, the fairy tale "Wonderful word media" tells about a meeting in the Forest Kingdom, where a group of children from the kindergarten is present.

"On the meeting, the animals said that they would like to know everything about their Kingdom: who lived, who and what ate, how many huts the inhabitants of the Kingdom had, and so on.

Owl, Wolf and Squirrel were involved in collecting such information. Animals and the Owl, a large clever bird, worked for a long time.

And later they wrote about everything they had found out in a book, as well as in a magazine and newspaper of the Forest Kingdom. They also reported on the Forest Radio and Television.

Just from magazines, newspapers, television, and radio the forest dwellers learned about everything that interested them. Not everyone has the opportunity to see Owl, Wolf or Squirrel to ask them questions. However, everyone could use a newspaper, magazine, radio or television program to find out how many huts is in the Kingdom, who and what dishes cooks and what food likes.

In the Forest Kingdom, newspapers, magazines, radio, and television were called a wonderful word media. The media, having received information about the life of the Forest Kingdom inhabitants from Owl, Wolf and Squirrel, retold the animals about what they heard and saw".

But more in the Forest Kingdom there was the group of children from the kindergarten. And they told the fairy-tale inhabitants that they could also get information... (children supplement: from a computer, tablet, mobile phone).

And then the kindergarten teacher with the children summed up. Newspapers, magazines, radio, television, tablet, Internet are called the word media. Media transmit information from those who have received this information to those who want to use it (Kuzma, 2020, p. 78).

Obviously, the safe use of media is the most painful problem that children face. Nobody really wants to limit himself/herself in time to play with a smartphone, a tablet. The fairy tale "A Hare and a smartphone" is devoted to this topic (Kuzma, 2020, p. 85). It tells the story of a Hare, who found a smartphone and completely devoted himself to the game. In this tale, the moral motives and security of the use of new media are closely intertwined. The Hare did not go to the Bureau of Finds, but played hard. At the same time, he ignored the rules of being in the Forest: he forgot about carefulness, fell into the clutches of the Wolf. The fairy tale also educates the ability to help and support each other (the animals freed the Hare as a group). In connection with the emergence of such a dangerous situation, preschoolers learn not to succumb to temptation (temptation and danger often walk together) (Kuzma, 2020, p. 85).

A fairy tale takes on a completely different meaning if the child is its hero.

In this fairy tale, the kindergarten group created advices for the forest animals, advised not to get carried away with smartphones, but to play on playgrounds, to help parents in the garden or at home.

Exactly media educational tale, in which a group of children and each child are the heroes of the fairy tale, strengthens the motivation for media education, which we used in the experimental model of the technology.

Thus, the enrichment of the educational complex has necessitated the specification of diagnostic tools for the formation of media literacy of older preschoolers. Identical to the term media literacy, we consider media competence.

2.3 Diagnosis of the Formation of Media Literacy of Preschoolers

On the basis of study of the works on the problems of diagnosing the formation of the preschool children personal qualities, the implementation of media education, analysis of media education competencies of preschool children, identified in Poland in the framework of the "Digital Future" project (Cyfrowa przyszłość, 2010), empirical studies, we presented the ideal result ideal result high level of media literacy formation), that we expect to achieve in preschoolers, as a result of media education. A preschooler with the formed media competencies is aware of the importance of learning about media and education through media and for media, analyzes media educational tales with interest, responds positively to the announcements about media education classes, computer as a media means, is aware of the diversity of media, knows how to receive information, how to distinguish truth from untruth in media messages, how to verify information authenticity, existing media threats; knows what property is that responsibility ensues for assigning the work of another author; critically analyses the media products for children is familiar with a computer, acquires basic techniques of working with it; is able to create media means (pictures, photo galleries, comics), showing creativity, analyzing it adheres to the rules of safe media usage.

Children of a sufficient level of media literacy formation, although not aware of the diversity of media, do not know how to receive information, how to distinguish truth from misrepresentation in media reports, how to verify the authenticity of information, that liability is incurred for the appropriation of the work of another author, but they are aware of the importance of learning about the media and education through media and for media. Their only media product, created independently, is a picture. They are experiencing positive emotions when using media products, agree to proposals for reading and discussing media educational tales, critically analyzing with their parents the media, adhere to the rules for the safe use of the media.

Without special educational influence the low level of media literacy prevails in children (misunderstanding of the importance of media education lessons, its benefits to the child, ignorance of the types of media, their functions, the choice of the source of information, ways of verifying the truth of the source, the ways of distinguishing the truth and lies in the media. Such children use mobile phones, tablets, gadgets without permission from parents, experiencing positive emotions when using media products, but do not want to analyze it, or analyze superficially. They show no interest in media educational tales. They do not show creativity while drawing (pictures are the only media work).

Formation of media literacy of older preschoolers is a complex process that involves a certain algorithm of actions for children, kindergarten teachers, parents, the implementation of special forms, methods, media education activities, diagnostic tools for checking whether the result corresponds to the aim. These actions and components are inherent to educational technologies. Thus, the actual task is to reflect the media educational technology at preschool educational institutions in the model.

2.4 The Model of the Media Educational Technology at Preschool Education Institutions

The research on the development and experimental verification of the media educational at preschool educational institutions was conducted during 2017–2020 (two stages: 2017–2018 – the first stage; 2019–2020 – the second stage) at the preschool education institutions of Ternopil (No 3, 16, 18, 19, Educational complex No 35), Khmelnytskyi (No 28, 29, 46), Kolkivtsi Educational complex (Khmelnytskyi region), Kherson (Educational complex No 7), Mukachevo (Educational complex No 1). Totally 384 respondents were involved in the confirmatory experiment (Yankovych et al., 2019). 225 children were involved in the formation experiment (2019–2020): 5 control and 5 experimental groups.

Some principles of the study of media literacy of preschool children were verified at Ternopil Volodymyr Hnatiuk National Pedagogical University at the Department of Pedagogy and Methods of Primary and Preschool Education and Khmelnytskyi Humanitarian Pedagogical Academy at the Department of Preschool Pedagogy, Psychology and Methods of Professional Disciplines.

A number of questions were asked to the children at the stage of the confirmatory experiment. The list of questions and answers to them is given in table 1.

On the basis of the analysis of answers to the first question “Do you know the word “media”? What do you think it is?” we concluded that the essence of the word is incomprehensible to children. 37 preschoolers out of 384 answered that the media is a TV, other 12 added that this is also a computer (but not a children’s magazine, book or theater).

Older preschoolers were asked: “If you want to learn about something how would you do it?” However, they could not answer this question without help. And only after the prompts “From the TV show ...”, “From the children’s magazine”, the answers were “from the computer”, “from the mobile phone”.

All children are aware that TVs often display distorted information, especially when it comes to advertising. However, they could not answer how to distinguish truth from untruth.

When asked how to check out whether what happens in life is described in fairy tales, children did not immediately answer that you need to ask your dad, mom, teacher. There was also such an answer: “One has to go with a mother or a father to the forest and check there, for example, whether a fox is talking to a hare”. What is said by a child is vivid confirmation of the fact that children have developed visual and effective thinking. Consequently, no child independently gave the correct answer to this question.

During the experiment, kindergarten teachers were asking: “Should children know that unusual events are reflected in fairy tales? Maybe, it is better for them to grow up with faith in the reality of the fair world”. We were answering that stereotypes formed in childhood often accompany people throughout their lives. For example, in adulthood, many adults are convinced that hedgehogs are wearing apples on their thorns. Such pictures were seen in books and magazines in childhood and remained in their memories as such that correspond to reality. Who defined the age when it comes to finding out the truth?”

During the experiment, we found that there is a direction in the field of media education, which kindergarten teachers give a lot of attention to in preschool education: child safety in the media and during contact with the media. Kindergarten teachers in preschool institutions talk about the threats of the modern digital means for the child’s organism. However, preschoolers often do not want to perceive and respond positively to such information, share it with their parents, who also prohibit the use of mobile phones, gadgets, tablets, etc. However, such devices increasingly attract children’s attention.

During the survey, all children answered that they like to read children’s books, magazines, watch TV and could not give preference to any single media product. Similarly, everyone answered that they like to talk about fairy-tale heroes, their acts, what they do well and what is wrong, but we have found in individual conversations that there is a need for a deeper critical analysis of such works, for example, whether the reflected events, in children’s opinion, are reliable.

Unfortunately, the only media product of preschoolers is the drawings, but they did not set the goal of using them to transmit information. In

Table 1: Survey results of preschoolers during the confirmatory experiment.

Content of the question	Number of positive responses and % of general quantity	Number of negative responses and % of general quantity	Note
1. Do you know the word “media”? What do you think it is?	0 0%	384 100%	49 (13%) answered inaccurately, incompletely
2. Do you know what are the ways to learn something, to get information?	0 0%	384 100%	(children with the help of tips partially answered the question)
3. Have you ever heard that what is written in newspapers, magazines, books, or shown on TV screens (for example, advertising) is not always true, and the authors of books, articles can make errors?	322 84%	62 16%	Only from television screens, mostly advertising
4. Do you know how to check the truth of what is written in children’s books, magazines, is shown on TV screens?	0 0%	384 100%	
5. How to check if what is described in fairy tales happens in life?	0 0%	384 100%	
6. Do you have a mobile phone? For what purpose do you use a mobile phone?	200 52%	184 48%	Phones are used for communication and entertainment
7. Do you know that you can use a computer, tablet, mobile phone to watch TV following certain safety rules?	384 100%	0 0%	
8. Do you play a mobile phone, do you use a computer, a tablet, watching TV violating security rules?	257 67%	127 33%	
9. Do you read children’s books, magazines?	384 100%	0 0%	
10. Do you love talking with your parents about fairy tales, their acts, what they do well, and what is wrong?	384 100%	0 0%	

addition, the children did not create together with their parents or kindergarten teacher’s newspapers, comics, as a means of conveying information. The role of a fairy tale is underestimated, in particular one that would acquaint with the media world, how to get the necessary information, distinguish truth from falsehood, and so on.

During the experimental study, a group of experts was created: a methodologist of an educational institution, a teacher and one of the parents who distributed the children by levels.

According to the results of the confirmatory experiment, conducted in 2017–2018, it was found that 246 (64%) children (in control and experimental groups) are at a low level of the media literacy formation; 138 children (36%) – at a sufficient level. Preschoolers of a sufficient level of media literacy had several advantages over low-level children: they followed the rules studied while using the media, showed creativity when creating pictures as a means of transmitting information, and critically analyze the media. However, in order to obtain a high level of media literacy, they lacked knowledge about the variety of media, how to distinguish truth from lie, how to verify the authenticity of information, the inadmissibility of appropriating the work of another author, lacking the ability to create newspapers, comic books and other media products, analyze them, and also realize the necessity of organizing special classes for the formation of such knowledge and skills. The results obtained during the confirmatory experiment determined the relevance of the development and implementation of the media educational technology.

As the technology, first of all, we understand a system, which has a clear algorithm of actions, we have identified the stages of it: diagnostic-target (setting the goals), integrational (work on the implementation of goals), and analytical (analysis of the results of the experiment on the implementation of technology).

The technology model is depicted in figure. It demonstrated the process of implementing media education of preschoolers in partnership with parents and kindergarten teachers from the goals to the result, using forms, methods, and means of media education activities, including the media educational tale as innovative media product (figure 1).

One of the main elements of the substantiated technology is the cycle of classes "Grains of Media Education" (supplemented by media educational tales), which is a part of the procedural component.

The organization of the experiment to test the model of technology provided for the methodical training of kindergarten teachers. For this purpose, special methodological guidelines and recommendations for kindergarten teachers were developed and used, in which both theoretical principles and practical approaches to the organization of the process of media literacy formation of children of the older preschool age in preschool institutions were developed and used. Kindergarten teachers, involved in the experiment, were instructed in detail about the essence of the experimental work in control and experimental groups. Traditional methods and programs were used in control groups; experimental groups implemented the developed technology model (Kuzma, 2020).

At the first stage, the diagnostics of the formation of children's media literacy in the control and experimental groups was carried out. In control groups and in experimental groups, no child was at the high level of media literacy. In control groups, 41 children (37.3%) out of 110 were at a sufficient level, 69 (62.7%) – at a low level of media literacy. In the experimental groups – 44 (40%) out of 115 children were at a sufficient level, 71 (61.7%) – at a low level of media literacy.

At the first stage, according to the diagnostics of the formation of media literacy among older preschoolers, the goals of media education were set.

At the second stage – integrational – the integration of actions of all the subjects of the educational process of preschool educational institution took place, the inseparability of the processes of motivation formation to media education, knowledge about media, their functions, a computer as the latest media tool, danger of the modern technical devices; skills of critical thinking and creation of the simplest media together with parents and kindergarten teachers.

At this stage, children with parents and kindergarten teachers read and analyzed media educational tales, media education classes were conducted for children: "Where do we get information from?", "Truth and untruth: how to distinguish", "Does Little Red Riding Hood really exist?", "What do you know about the copyright of the authors of books?"

During the media education class "Where do we get information from?" preschoolers found out about the essence of media, its types; how beneficial they are to a child, realized that there are many sources of information; learned to choose the source of information according to their needs; tried to find another source of information than from an older person. Since preschoolers are thinking specifically, it is not necessary to demand from them to remember the meaning of the word media.

Therefore, the knowledge of the essence of the concept of media was not tested during the experiment. However, as a result of experimental work, preschoolers have learned that not only TV, but children's magazines, booklets, theater is also media. Every day a preschooler is receiving a variety of new information. The kindergarten teachers told children that they could learn a lot, not only by asking parents or adults, but also flipping children's magazines, watching television programs. The class helped to find out what are the ways to find information.

The media education class "Truth and Untruth: How to Make a Difference?" was difficult for older preschoolers. Its goal was to get the children to know: not all that we learn is true; therefore, one has to learn to check information. After completing the training, preschoolers developed the ability to formulate simple questions to verify the accuracy of information; knew whom to contact to verify truthfulness of information; critically perceived information.

The media education class "Does Little Red Riding Hood really exist?" was an interesting one for the children. The kindergarten teachers told the children that not everything described in the fairy tale is true. After the class, the children knew that the actors from TV screens or magazines and books with whom they got acquainted could be fictional; heroes of fairy tales are also fictionalized.

Children can often distinguish between truth and untruth in fairy tales. But they do not always succeed. During the class, they become convinced that the author of fairy tales is inspired by the real world, for example, the world of animals. Preschoolers can create their own hero through their imagination.

When the experiment began, we thought that the main problem in implementing media education in preschool is the lack of interesting educational and

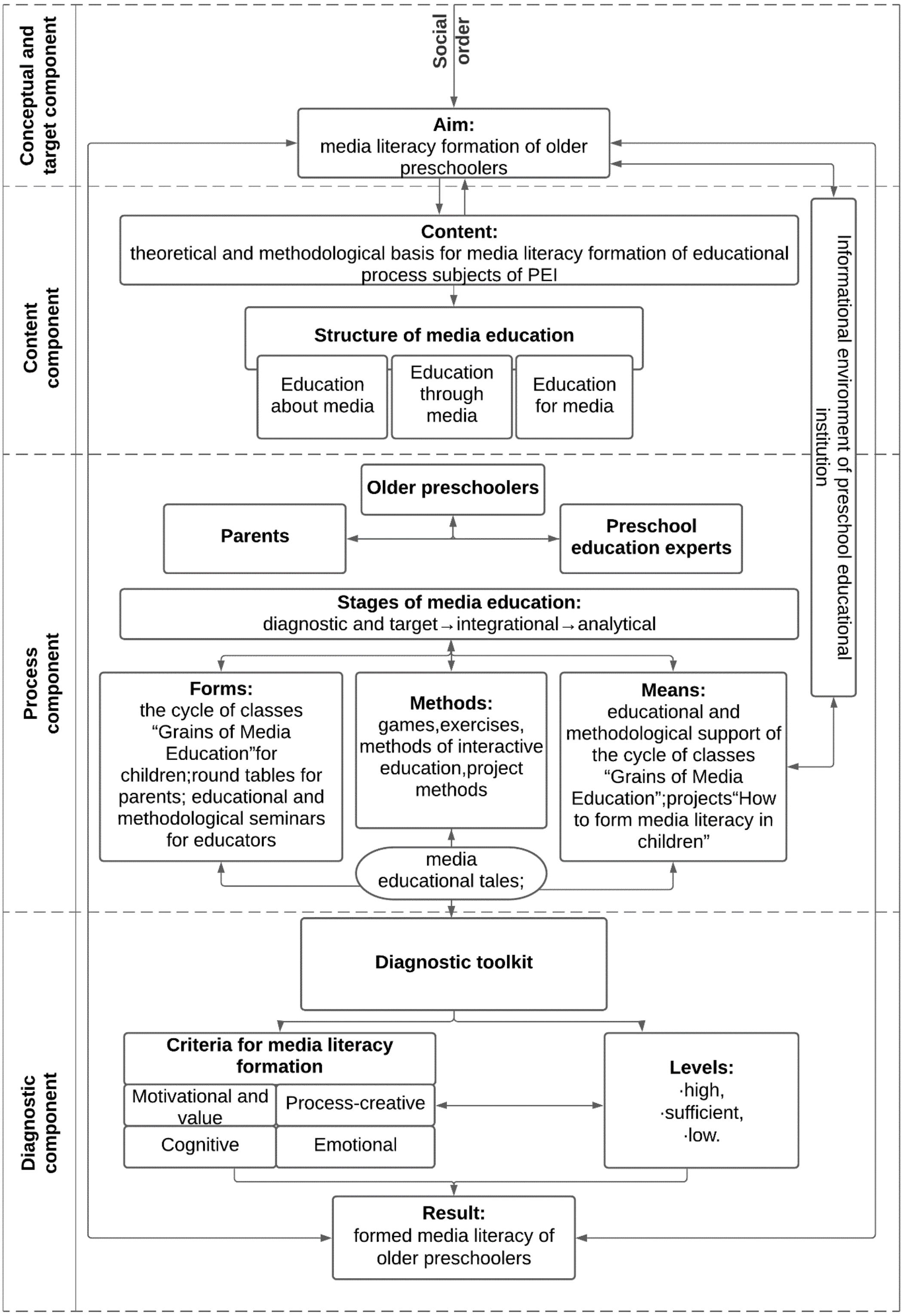

Figure 1: Media educational technology at preschool educational institutions.

methodological support. Therefore, by substantiating the media educational technology, we developed it and named as “Grains of Media Education”.

The name of the methodological support “Grains of Media Education” itself testifies that children develop elementary knowledge and skills that will become the basis for media education in elementary school. We implemented various media education trends, borrowing the experience of Polish pedagogy: using information, relations and communication in the media environment, media language, creative use of media, ethics and values, legal and economic aspects of media use (edukacjamedialna.edu.pl, 2021).

It has already been pointed out that the problems of media education are challenging not only for children, but also for parents. When reading the methodological development “Grains of Media Education”, parents had possibility to find out what media education is. Parents together with children and kindergarten teachers acted on the principles of pedagogy partnership, using the information environment of a preschool educational institution.

During the experiment, promising ideas of the experience of the children’s media literacy formation in preschool institutions of Ukraine were realized, in particular, the creation of a photo-paper “My Family Tree”, a comic book “One day from my child’s life”.

Children not only acted as the authors of comic books, but also as their characters. For example, one of the preschoolers performed as a doctor, and the kindergarten teacher (his father) was taking photos of him during his work. Then a series of comics was created from the photos.

A child, due to the comics, learned to distinguish between two types of text information: language and thought.

One of the comics topics was: “A TV is My Friend”. At the same time, children found out that the TV did not only a medium that transmits information and affects children. It was illustrated as the following: a father calls his child to eat, or to read a book, to wash, but the child had the only answer: “No, let’s watch the cartoons”. In the end, the children saw the result of such behavior: a pale, frustrated face, poor eyesight, headaches, distorted spine. In the picture the child is yelling: “OK, let’s turn off the TV and go to the garden”.

During the experiment, we trained preschoolers to avoid extremes: not to consider everything seen on the TV as untruth, and not to believe everything entirely what they saw or heard in the media; to choose elder people (parents, kindergarten teachers, etc.) to verify the correctness of the information.

At the analytical stage, the media education activities of the subjects of the educational process of the preschool educational institution were analyzed. After the experiment was carried out, the positive changes in the dynamics of levels of media literacy formation were observed: in experimental groups, 24 children (20.9%) were at a high level of media literacy, 71 children (61.7%) were at a sufficient level; 20 children (17.4%) were at a low level of media literacy. In control groups, 44 children (40%) were at a sufficient level, 66 children (60%) had low levels of media literacy.

In the control groups, the distribution of children in the groups, which was recorded during the confirmatory experiment, has almost not changed.

The dynamics of the formation of media literacy levels is presented in table 2.

Thus, the research has proved the effectiveness of implementing the media educational technology at preschool educational institutions.

After the experiment we came to the conclusion that children are more likely to analyze media production with their parents and kindergarten teachers, they are more interested in magazines.

Significantly (by 44.3%) in the experimental groups decreased the number of low-level media literacy. Instead, one in five children has a high level. Compared to the first stage of the experiment (2017–2018) during the second stage (2019–2020), the number of representatives of the low level of media literacy in the experimental groups decreased by 10.6% (it was 28% during the first stage, it became 17.4% after completion of the second stage) (Yankovych et al., 2019).

However, during the experiment, we realized that a new form of work – reading and analysis of media educational tales – increase the motivation of kindergarten teachers to media educational activities. At the same time, the problems have remained. Kindergarten teachers are primarily trying to implement the State Standard for Preschool Education (it is gratifying that critical thinking is now mentioned as a crosscutting skill of preschoolers), and also do everything to meet the expectations of parents. Traditionally, parents want their children learn to read, write and count in preschool educational institution. Consequently, it is precisely for this purpose that their main efforts are directed. The obstacle for media education is the high level of groups filling (up to 35 children in a group) in the preschool educational institution. Tired of the difficult work, during which it is necessary to constantly meet the requirements of parents, methodologists, managers, kindergarten teachers often do not want to assume additional responsibilities for the implementation all directions of media education. And

Table 2: The dynamics of the formation of media literacy levels of the older preschool children.

Levels	**Control group (110 children)**		**Experimental group (115 children)**	
	Before experiment	**After experiment**	**Before experiment**	**After experiment**
High	–	–	–	24 (20.9%)
Sufficient	41 (37.3%)	44 (40%)	44 (38.3%)	71 (61.7%)
Low	69 (62.7%)	66 (60%)	71 (61.7%)	20 (17.4%)

after that we look forward to enthusiasts, especially those who were trained, attended the courses at the Academy of Ukrainian Press.

Studies conducted in higher education pedagogical institutions among undergraduate part-time students (more than 90% of them are kindergarten teachers) have shown that they do not know what media and media education are. Only 2% of the polled masters are familiar with the Concept of Media Education Implementation in Ukraine. Approximately 50% of the masters-kindergarten teachers who are part-time students are convinced that media education is education with the help of the state-of-the-art computer technology (Yankovych et al., 2018).

All the students we have interviewed were women aged 23 to 46. Studies were conducted only in absentia, since more than 90% of the students of this form of study work as kindergarten teachers and must implement media education. But in reality, they have a very low awareness of media literacy.

Consequently, on the one hand, kindergarten teachers need to increase media literacy, on the other hand – they have insufficient motivation for this. The exception is such a direction of media education as the prevention of threats of the modern computer equipment for a child, which is not surprising, because this is one of the tasks of the kindergarten teacher, defined by the State Standard for Preschool Education.

Thus, the research has shown, on the one hand, the feasibility of implementing the media educational technology at preschool educational institutions, on the other – the need for further education of future kindergarten teachers; creating better working environment for them. However, the fulfillment of the latter task depends on the economic development of Ukraine; of the funds that will be invested in the educational sector.

3 CONCLUSIONS

The manipulation of the consumers' media consciousness, the saturation of television programs by the scenes of aggression and violence, the uncontrolled use of modern technical devices by children already at preschool age, determine the relevance of media education, which results in the formation of media literacy (preschooler's awareness of the feasibility of media education classes and their positive attitude towards their realization, knowledge of media diversity, its functions, computer as the latest media tool, awareness of the threats of modern technology, the ability to choose sources of information, create photo papers, comics, drawings, fairy tales, critically, consciously and responsibly perceive information).

The research has proved the necessity of implementing the media educational technology at preschool educational institutions, the cycle of classes "Grains of Media Education", the content of which is supplemented by media educational tales as a printed innovative media product. The effectiveness of the technology is confirmed by the positive dynamics of the levels of media literacy formation. Before the experiment, 61.7% of children were at a low level of media literacy, 38.3%) – at a sufficient level. No child was at a high level of the media literacy formation. Due to the implementation of the developed technology, 20.9% of children achieved a high level of media literacy development (61.7% were at middle and only 17.4% – at low levels). The number of children at low level decreased by 44.3%.

The analysis of the results of experimental work confirms the necessity of raising the level of media literacy of the kindergarten teachers themselves who need to improve the conditions of professional activity, as well as finding non-starting solutions, developing innovative products for the implementation of media education.

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Features of the Use of Software and Hardware of the Educational Process in the Conditions of Blended Learning

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Abstract: The paper reveals the results of a study of the feasibility of using software and hardware for the educational process in a blended learning environment in secondary, higher and vocational education. The author conducted an analysis of domestic and international research on distance learning (distance learning needs, requirements for distance learning platforms, experience in implementing distance and blended learning). In the course of the research, the author revealed the standard composition of modern software and hardware of the educational process in the conditions of blended learning and analyzed the market of Ukraine for the availability of ready-made complexes of the company. Recommendations for approaches to teaching in each age group of students and approaches to choosing a complex for implementation in a mixed and distance learning environment, taking into account the individual needs of each educational institution or educational organization. The research is theoretical in nature and designed to create a basis for further research in a given vector.

1 INTRODUCTION

2020 was a year of testing in all areas of human activity, a year of renewal and strengthening the level of informatization of these areas (Fedorenko et al., 2019). The reason was the global pandemic of the COVID-19 virus (Semerikov et al., 2020), which served as a catalyst for the informatization of life. Speaking about the general informatization and problems of COVID-19, we can emphasize that the greatest impact was suffered by such areas of human activity as: education, medicine and industry. As part of our study, we will focus on identifying the problem of the education sector, as well as methods for solving them in full or partial quarantine.

Having conducted a preliminary analysis of the problem, we can already emphasize the significant tendency to increase the number of scientific papers that focused their research on the development and implementation of adaptive testing systems for students, the use of automated learning systems and development of quality learning environments (Osadcha et al., 2020; Pererva et al., 2020; Vlasenko et al., 2020b). However, we can emphasize that the development of such systems significantly improves the worldview of people in the study of theoretical or informational courses, but not in the context of teaching higher education students or high school students in subjects that require physical, creative or group work. We can say that the learning process, especially in secondary and vocational education requires closer contact with the teacher and creating conditions for full immersion in the educational process, which is the task of our study: to analyze the specific learning needs in blended learning and determine the appropriateness of the selected set techniques for creating a blended learning environment in secondary and vocational education.

The first stage of the work was the analysis of current research in a particular area. The leading tasks for the analysis were determined: in-depth analysis of modern needs of distance and blended learning processes; analysis of the experience of using the means of creating a quality educational process in terms of distance and blended learning. Defining these tasks for analysis, we expected to get a comprehensive and comprehensive vision of distance and blended learning and ways to solve it, as well as analyze the world and domestic experience of using tools

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to create a quality learning process in distance and blended learning.

Bobyliev and Vihrova (Bobyliev and Vihrova, 2021), Bondarenko et al. (Bondarenko et al., 2018), Gonchar (Gonchar, 2012), Osadchyi (Osadchyi, 2019), Osadchyi and Varina (Osadchyi and Varina, 2020), Tkachuk et al. (Tkachuk et al., 2020), Valko and Osadchyi (Valko and Osadchyi, 2020) focused on determining the fundamental foundations of development and conducting distance or blended learning. Important in the study was the analysis of works on the experience of developing and conducting training during blended learning in general quarantine, among these works, important in our study were noted works (Kruglyk et al., 2020; Lisachenko et al., 2020; Tkachuk et al., 2020). Exploring the world experience of using tools to create a quality learning process in distance and blended learning, we can note the works (Bliuc et al., 2012; O'Connor et al., 2011), in which scientists have described in detail the issues of blended learning, its problems and needs. Comas-Quinn (Comas-Quinn, 2011) analyzed in his work the experience of teachers in a blended course using the means of synchronous and asynchronous communication. Kirkley and Kirkley (Kirkley and Kirkley, 2005) conducted a detailed analysis of the processes of creating a mixed learning environment using mixed reality, video games and modeling the results of production processes.

After the analysis, it was decided to check the feasibility of use and develop recommendations for the use of the complex identified in the study.

2 FEATURES OF THE USE OF SOFTWARE AND HARDWARE OF THE EDUCATIONAL PROCESS IN THE CONDITIONS OF BLENDED LEARNING

An important point in creating a system of learning in distance and blended learning is the motivating factor. In the modern psychological and pedagogical literature, the following elements of the motivating factor are allocated: creation of the accurate target installation; an indication of the need for action to study specific course topics and for professional activities; selection of educational content in accordance with the cognitive interests of students; providing professional orientation of this content; ensuring the optimal level of requirements for each course. To activate the cognitive processes of attention, perception, thinking, there are a number of other requirements: to provide educational information with a high enough redundancy; use technical teaching aids; use computer technology; take into account the possibility of direct control of perception; take into account the emotional factor. According to scientists, the essence of creative psychological and pedagogical technology is a creative approach to solving the problem of pedagogical process, during which the interests and values of the individual are one of the dominant components of the organization and content of educational activities (Gonchar, 2012; Osadchyi and Varina, 2020; Lisachenko et al., 2020; Bliuc et al., 2012; Kirkley and Kirkley, 2005; Bukreiev, 2020; Vlasenko et al., 2020a). That is, we can say that creative psychological and pedagogical technology actually speaks of a paradigm shift in vocational education, where it will be necessary not to solve ready-made didactic tasks, but to generate, initiate, creatively formulate ideas, plans. In order to solve this problem, there is a need to analyze the existing software and hardware of the educational process in terms of blended learning and the development of methodological complexes for its use.

According to the current epidemiological situation, the needs of educational institutions and the problems of blended learning, we can note that in general the optimal performance of the blended learning class can be represented in the form of such a structure (figure 1).

The need of educational institutions in partial or complete quarantine leads to full or partial transfer of the educational process to the Internet, which in turn reduces the level of involvement, motivation and concentration of students in the educational process. The reason for this trend is, first of all, a decrease in the level of perception of information and a change in the classroom environment to a relaxing home atmosphere. To solve this problem, it is advisable to turn to the works of Kruglyk et al. (Kruglyk et al., 2020), Osadchyi and Varina (Osadchyi and Varina, 2020), Valko and Osadchyi (Valko and Osadchyi, 2020), who emphasized the need to create conditions for quality and in-depth communication between teacher and student in a blended learning environment. Kruglyk et al. (Kruglyk et al., 2020) conducted an experimental test of the implementation of the remote communication platform Discord and according to the results of the experiment stressed the significant positive trend of improving the quality of students' knowledge, after the introduction of a new platform for remote communication active synchronous communication, group work and individualized consultation with the teacher. Analyzing the results of the experiment, we can em-

Figure 1: Class model of an interactive lesson in the conditions of blended learning.

phasize that creating conditions for partial immersion of students in the initial process in distance education, by creating virtual classrooms, significantly increases the quality of information perception, by interacting with almost all organs of student information perception. Thus, the need to create conditions for expanding the reality of the educational process in terms of blended and distance learning is confirmed.

To create conditions for expanding the reality of the educational process in mixed and distance learning, between full-time and distance students, we analyzed the modern software and hardware of the educational process in mixed learning and the possibility of its implementation in the educational process. First of all, we analyzed the experience of conducting classes in quarantine on the basis of various educational organizations. It is worth noting three main approaches that were analyzed during the study, namely: full distance education on the basis of Bogdan Khmelnitsky Melitopol State Pedagogical University, mixed form of education on the basis of schools in Melitopol, full-time education on the basis of robotics class for students primary school and direct education of primary school students. In terms of age gradation, only within the study, we can conditionally divide students into three groups, respectively: junior students (full-time), middle school (mixed form of education) and senior students (distance learning). Accordingly, this distribution is quite logical and determined by current trends and experience of teachers, which we observed during 2019-2020 during the quarantine caused by COVID-19.

Having divided into groups of levels of education and age category, we can determine the main needs of each group, and analyze the experience of their satisfaction.

The first group was selected to conduct an analysis of younger students, due to the low level of changes that have been introduced into the educational process after the introduction of global quarantine. We can note that the main problem was and remains the low level of ability of primary school students to concentrate on the learning process, the need for constant active interaction and the use of game approaches. The current measures to increase the level of concentration are the use of animation and game interaction of students with the object of study. By solving this problem, we can note the special information and pedagogical tools of the New Ukrainian School. Based on the analyzed experience, we can note the active introduction into the educational process: interactive panels, electronic tablets, projectors with the ability to remotely control and combine into a single network and other means of game learning. Teachers, through the use of visualization technologies and interaction of the student with the object of study, create conditions for full deepening and concentration of the student's attention in learning, allowing the disclosure of all cognitive styles of the student through comprehensive interaction. In this case, the teacher acts as a moderator of the game and a judge on the quality of its performance, students act as players or observers, which significantly increases their concentration on learning and motivation to participate in the "learning game".

If we analyze the experience of robotics classes, we can note a number of specific needs caused by the peculiarities of the club, to them we can note the need for mobility (conducting classes on the basis of various educational institutions) and the availability of low-load mobile software to solve problems of insufficient capabilities of computers on the basis of small schools in the city. The solution to this problem may be to use a set of software and hardware, which consists of: a set of mobile computer tools (laptops or tablets) with software installed on them for robotics, sets of constructors for robots and means of displaying information (multimedia panel with fixed mobile rack or projector with screen).

The second group focuses its work on creating conditions for expanding the reality of students in blended learning. The reason for the problem is the practice of Ukrainian schools to conduct classes in the format of dividing the group into two parts that gradually replace each other. Summarizing the model of the lesson of this group, it is expedient to display it as a model of a spiral of two rays, in which the rays are constantly changing their position. This creates the conditions for reducing the number of students who are in the classroom at the same time and conducting classes for half of the students in a distance format. Each week the groups change places and the process moves from full-time and distance learning formats to general blended learning. This approach is highly appropriate in terms of maintaining the health of children, but imposes a significant reduction in the level of concentration of students in the learning process, which leads to a decrease in the level of knowledge of students in general. In order to solve this problem, we analyzed the possibilities of modern software and hardware in combination with the experience of Ukrainian schools. According to the analysis, we can emphasize the insufficient level of elaboration of a particular issue and the lack of a clear solution to the problem. One of the leading reasons, in our opinion, is the low level of motivation of students to learn. Constant work at home creates conditions for reducing the concentration of students, which leads to a complete lack of motivation and fatigue from tasks. To address the root cause, there is a need to fully modernize learning and create a comprehensive learning platform. In our opinion, it is advisable to use the means of augmenting reality and the introduction of a single face-to-face learning space, which is achieved through the use of: a single information platform with educational and methodological complex, permanent webcams for students studying at home, the introduction of constant intensification of their work over group projects with students in the classroom. This approach significantly activates the cognitive processes of students and requires them to fully concentrate in order to achieve positive results of the group. However, the problem of a certain approach is a significant increase in the role of the teacher during classes, students will be able to fully unleash their potential only if the quality of development of teaching materials. In our opinion, teaching materials for blended learning should be based on three main postulates: dynamism, ease of understanding and group interaction. Thus, the software and hardware component of training must meet the conditions of dynamic visualization of information and the possibility of active interaction with it (the use of dynamic 3D models, learning animations, the ability to add and change control factors, etc.), examples of such existing initial software can be considered such programs as: ActivInspire, ClassFlow, mozaBook and others.

As part of the work of the third group, we can note a significant change in the format of the educational process with the transfer of the entire educational process to distance learning. This approach fully protects students from the possibility of further spread of the virus, but creates significant problems for the quality of education. The cause of these problems is the complete isolation of students from teachers, which creates conditions for emotional isolation of students, which leads to a complete or partial reduction in the level of concentration of students in the learning process. To a large extent, these processes are based on the insufficient level of development of students' self-awareness and their motivation for the process of acquiring knowledge. Unfortunately, we can say that there is no possibility of a complete solution to the problem due to the large age of students, while the process of self-awareness should develop from an early age, however, analyzing the experience of classes at the Department of Informatics and Cybernetics Bogdan Khmelnitsky Melitopol State Pedagogical University, we can emphasize the existence of a number of methods to improve the quality of knowledge and motivation of students to learn. In our opinion, the priority is to create conditions for quality and open communication between teacher and students during training and the possibility of simultaneous work (virtual classroom, platform or server) with a large number of information flows (desktop of each student), so in work (Kruglyk et al., 2020) reveals the features of the Discord platform implemented on the basis of the above mentioned department. Based on the results of the study, we can note that the main need for distance work is to create conditions for synchronous communication using a single database of teaching materials (for example, the site of distance learning https://dfn.mdpu.org.ua), the availability of remote assessment and the ability to dynamically display the results of work. To increase the level of information visualization, it is advisable to use broadcasts of 3D models and examples of problem solving during lectures. For this purpose, on the basis of the Department of Informatics and Cybernetics, a multimedia panel with the mozaBook application installed on it was used, from which the broadcast for all students of the study group took place. The task of the teacher in terms of distance learning is the function of the developer of educational and methodological support and the lecturer during lectures. The main problem is the need to develop standardized tasks that would be interesting for "strong" students and with a sufficient level of complexity for "weak" students. It is important to take into account the cognitive styles of different groups of students, to create conditions for high-quality perception of information by all students and to solve problems in different ways. A separate problem is the problem of low level of technical support of students and problems with the Internet (Kruglyk et al., 2020). The solution to the problem is the use of the teacher, in the educational process embedded learning servers with the ability to teach learning materials for asynchronous interaction and perform or test tasks at a convenient time for the student and teacher. However, as we emphasized the need for synchronous interaction between teacher and student to improve the level of information perception and interaction with the cognitive styles of each student. This in turn creates a contradiction between the synchronous and asynchronous approach to learning. To resolve this contradiction, there is a need to combine both approaches and their parallel implementation in the educational process. This decision increases the requirements for the teacher in terms of psychological and pedagogical training, development of universal methodological complexes and the introduction of innovative pedagogical tools in the educational process. An additional problem is the need to determine the cognitive characteristics of students and adjust the learning process in accordance with the results of this definition, which has been studied by Sender (Sender, 2018).

Therefore, summing up the requirements of all approaches to learning in a mixed distance learning environment, we can say a partial or complete exclusion of methods and means of face-to-face interaction, in order to reduce the possibility of infection with the virus. The methodical work of the teacher should be focused on the issues of psychological and pedagogical preparation for the educational process, development of universal methodical complexes and introduction of innovative pedagogical means in the educational process. When trying to determine the form of the general complex of software and hardware of the educational process in the conditions of mixed learning, it includes: means of information visualization (physical board in combination with a webcam, multimedia board, projector), means of training and control unit (laptop, computer computer, tablet, training server), means and methods of synchronization of the educational process (online testing, use of the general training server, screen demonstration), platform of synchronous and asynchronous communication (Discord, Zoom, Google Meet and others), educational and methodical complexes, training programs with Internet access (distance learning site, ActivInspire, ClassFlow, mozaBook and others). We can note that a certain set of software and hardware in different combinations of the composition in general solves the problem in the study. We have developed models of three sets of software and hardware for each of the approaches studied in the work. Each of their complexes aims to create conditions for a quality learning process in a blended learning environment, but each of them has a unique and narrow link of use and should be selected according to the unique needs of each type of educational activity.

Thus, the interactive multimedia complex for the younger group, which includes an interactive panel, laptop, webcam and training software, allows you to easily perform the lecture load in a distance and blended learning environment. However, determining the needs of professional education, which are noted in (Gonchar, 2012; Malchenko et al., 2021; Tkachuk, 2018; Valko and Osadchyi, 2020), the defined complex does not fully realize the possibilities of mobility and creative immersion in the educational process by the students themselves, which in turn significantly reduces the possibilities of its use. The use of a certain complex will require the teacher to develop more in-depth methodological materials in order to solve a certain problem, create conditions for group work and artificially expand the worldview of students during their studies. However, such a complex provides the minimum necessary functions that fully meet the needs of the younger group of students.

Interactive multimedia complex for the middle group, which includes an interactive panel, laptop, webcam, document camera, 4G modem, unlimited internet and training software. We can emphasize the high level of capabilities in the vector of classes in mixed or remote mode, provided that there is a static laboratory or office for classes. The presence of 4G Internet units and two types of cameras, create conditions for partial immersion in the learning process, the student has the impression of actual presence in the classroom as close as possible to real events, which fully meets the needs of vocational education and solves the main problems of blended and distance learning, indicated in (Bliuc et al., 2012; O'Connor et al., 2011). Therefore, we can emphasize the feasibility of using a certain complex during the educational process of secondary, higher and vocational education in blended and distance learning. The introduction of a certain complex in higher education institutions in order to intensify learning, by increasing the level of visualization and direct immersion in the work process is a productive and promising area. We believe that the implementation of the complex will increase the level of motivation of students to learn and intensify their educational activities, which in turn will confirm the positive impact of reality on the quality of students' knowledge while studying in distance and blended learning.

Interactive multimedia complex for blended learning for the senior group, which includes an interactive panel, a stand on wheels, means of remote input of information, a virtual classroom, a separate operating system, means of screen demonstration. In a certain complex, we have the opportunity to note the high level of mobility and technical capabilities. A modern multimedia panel in combination with a computer module will create the conditions of a high-tech mobile learning station without the need for the physical presence of some participants in the learning process in a static audience. This, in turn, expands the opportunities for teachers and students and creates conditions for field trips, classes in conditions of constant partial lack of information, classes in the format of electives, after classes, training groups and more. This in turn will expand the age range of students and the range of approaches to learning, which is especially important for institutions of higher and non-formal education.

However, along with the problem of insufficient software and hardware base of modern educational institutions in Ukraine, there is a problem of insufficient funding. In this regard, we analyzed the most common ready-made complexes for blended learning, in order to determine the possibilities of solving the main problem of research through their use, which are freely distributed in Ukraine. The analysis highlighted that Promethean and EdPro are the leading companies. Thus, we marked the four most optimal educational complexes:

1. Interactive multimedia complex for blended learning 5 in 1 Promethean: interactive panel, laptop, webcam, ActivInspire, ClassFlow (96936 UAH) (figure 2).
2. Interactive multimedia complex for blended learning 7 in 1 4G Promethean: interactive panel, laptop, webcam, document camera, 4G modem and unlimited internet, ActivInspire, ClassFlow (UAH 170,000) (figure 3).
3. Kit for blended learning 7 in 1 Mobile Promethean (UAH 175,000) (figure 4).
4. Interactive panel EdPro ETP65L52568 (UAH 132,444): Screen 65 " 4K, 20 Touch, Intel® i5 8gen, 256 GB SSD, 8 GB RAM, stand on wheels, wireless combo keyboard, MozaBook Classroom, Windows 10 Pro UKR, Note & Connect & ScreenShare Pro (figure 5).

We emphasize that the complexes were developed by companies with the aim of maximum standardization, which can significantly affect the quality of education in each area of education. However, we can emphasize the expediency of using these complexes in the conditions of mixed and distance learning, only if the individual needs of each educational institution or educational organization are taken into account in advance. This creates a need for further study of a particular problem, in order to generalize a single productive complex within each of these approaches to learning in blended and distance learning.

3 CONCLUSIONS

According to the results of the study, we can say that the analysis of scientific sources in combination with the subsequent analysis of the capabilities identified in the work of interactive multimedia systems for blended learning gave us the opportunity to say that all identified systems are appropriate for implementation in the learning process training taking into account the individual needs of each educational institution or educational organization. As part of the study, students were divided into 3 conditional groups: junior students (full-time), middle school (mixed form of education) and senior students (distance learning) and developed recommendations and described the experience of learning in each of the identified groups. Then the standard structure of the software and hardware complex necessary for creation of conditions of qualitative training was analyzed and complexes for each of the certain groups were developed. In our opinion, the use of such complexes in higher education institutions in order to intensify learning will significantly improve the quality of students' knowledge through visualization and direct immersion in the work process. We believe that

Figure 2: Interactive multimedia complex for blended learning 5 in 1 Promethean.

Figure 3: Interactive multimedia complex for blended learning 7 in 1 4G Promethean.

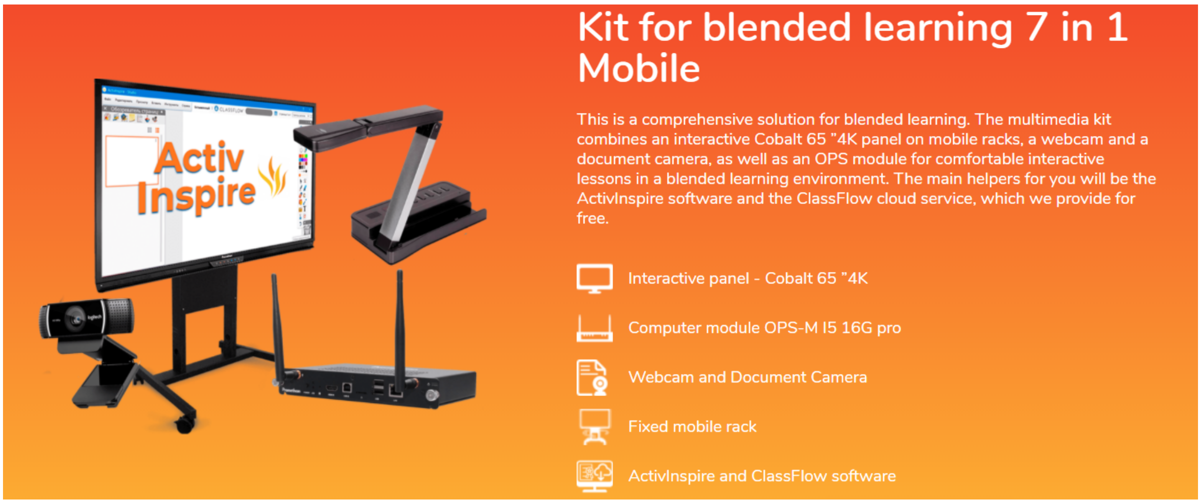

Figure 4: Kit for blended learning 7 in 1 Mobile Prometheang.

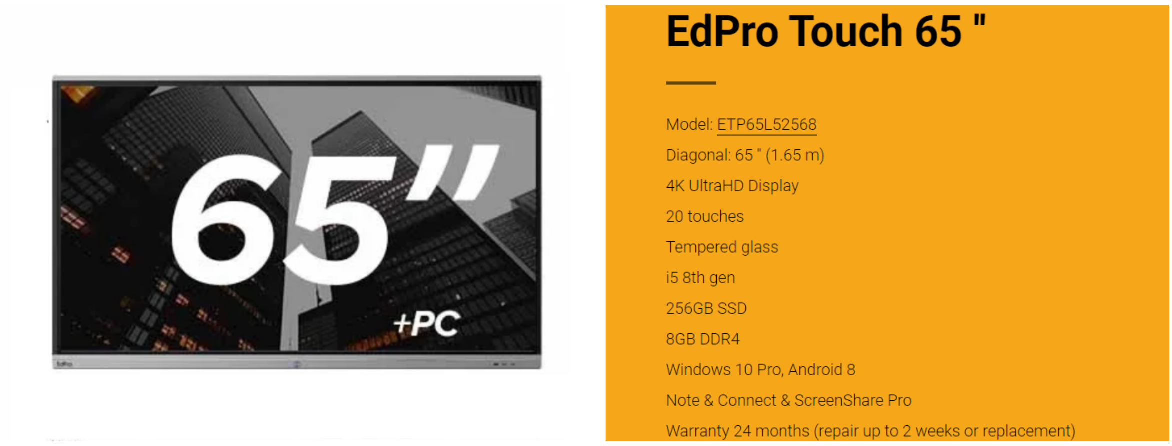

Figure 5: Interactive panel EdPro ETP65L52568.

the implementation of the complex will increase the level of motivation of students and intensify their educational activities, which in turn will confirm the positive impact of augmented reality on the quality of students' knowledge during distance and blended learning. However, in the future a detailed study of the specific needs of each branch of education is needed in order to determine the optimal use of the analyzed complexes or the development of a new complex in order to maximize learning productivity. Thus, a system of full immersion of students in the educational process will be created and all the needs of educators will be covered to create a quality educational environment in the conditions of long-term blended or distance learning.

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Web-based Support of a Higher School Teacher

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Keywords: Mathematics Teachers, Types of Activities, Web-Tools, a Personal E-Learning Environment Model.

Abstract: The article looks into the issue of theoretical aspects of using Web 2.0 technology in higher education. This paper describes the answers of 87 respondents who have helped to find out the types of activities that higher school teaches carry out and determine such Web 2.0 tools that can make this activity full. The authors carry out a theoretical analysis of researches and resources that consider the development of theoretical aspects of using Web tools in higher education. The research presents the characteristics common to online courses, principles of providing a functioning and physical placement of online systems in Web space. It is reasonable to make a conclusion about the feasibility of promoting online courses, the aim of which is to get Mathematics teachers acquainted with the technical capabilities of creating educational content developed using Web 2.0 technology.

1 INTRODUCTION

With the emergence of Web education, scientists have faced an important task which is to create a perspective new system of education. The use of teaching aids in the educational process, based on using Web 2.0 tools, has enabled it. Rosen and Nelson (Rosen and Nelson, 2008) have stated that these tools have a great potential for education providing a new quality of students' self–study.

Yadav and Patwardhan (Yadav and Patwardhan, 2016) have stated the actuality of Web 2.0 technology during education, while analyzing an economically profitable solution to the integration of their tools.

University Mathematics teachers are not an exception, since their professional activity comprises not only teaching students, but also doing research, analysis, and statistical processing of the information, doing calculations, publishing research papers, popular science materials, presenting reports and materials, communication and collaboration, etc. but, according to (Bennett et al., 2012; Yadav and Patwardhan, 2016), teachers mostly are not familiar with social media and other useful resources of Web 2.0. Livotov (Livotov, 2015) has raised issues connected with the pedagogical use of Web 2.0 technology. In the scien-

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tist's opinion, despite all the barriers of involving such services, Web-oriented education is a rapidly growing educational area. With the help of these services, we can offer a bright educational environment created with the use of different strategies and technologies of education. While making a selection of Web-resources, every person has an opportunity to design Personal Learning Environments (PLE) according to their line of work. All things considered, mastering new resources and designing their PLE calls forth timeliness of developing methods and ways to help and support Mathematics teachers.

We have investigated the experience of scientists who have contributed to the implementation of Web technologies in higher education. Carrying out such analysis we have studied recommendations by Kompen et al. (Kompen et al., 2009) who point out the importance of describing Web 2.0 tools and services that may be chosen to collect and process the information. Tautkevičienė and Dubosas (Tautkevičienė and Dubosas, 2014) have emphasized the need to develop such Web 2.0 tools that will encourage students' desire for publishing and sharing the knowledge created by them.

Among studies on the methods for designing Personal Learning Environments, the ones focused on designing PLE for schoolers and students prevail. Their goal is e-learning, remote, or non-formal learning. Thus, Kompen et al. (Kompen et al., 2019) drafted general guidelines for the implementation and use of the personal learning environment by students in a formal format in higher education (University level). Alharbi et al. (Alharbi et al., 2013) tried to allow students to design their technologies of PLE, such as blogs, websites, and Web 2.0 services. The researchers offered a model for designing PLE, which covers both traditional formal (in Universities), and informal (private) academic learning.

Shaikh and Khoja (Shaikh and Khoja, 2012) emphasize the necessity to study the role, which a teacher plays in the learning process. The researchers outline the competencies, necessary for teachers who help students plan or design Personal Learning Environments. Couros (Couros, 2006) holds the same opinion and states that a teacher can provide online learning better if they designed their PLE model.

Building a teacher's PLE model requires understanding the essence of the term Personal Learning Environments. There are different approaches to determine it given in (Attwell, 2007; Drexler, 2010; van Harmelen, 2006; Kompen et al., 2019; Segura and Quintero, 2010; Shaikh and Khoja, 2012), but there is no general definition of the term PLE.

The authors of this article will follow a definition, suggested by Kompen et al. (Kompen et al., 2019), who consider PLE to be a set of Web-technologies having a different level of integration and which help users manage the flows of information on education, knowledge creation, and skills development. Such an approach, according to Perikos et al. (Perikos et al., 2015) will help to identify the most suitable tools to create content for PLE. Moreover, scholars firmly believe, that such research will contribute to the development of educational online courses on how to use Web 2.0 tools. Following the conclusions made by scientists, we can see the use of such an approach to develop online courses with the purpose to prepare higher school Mathematics teachers. Relevance and timeliness of the issue to design PLE for Mathematics teachers was discussed during the International Conference on Sustainable Future: Environmental, Technological, Social and Economic Matters (ICSF 2020) (Vlasenko et al., 2020b), the participants of which concluded the necessity to develop and implement online support for Mathematics teachers in designing PLE.

According to the research conducted by Vlasenko et al. (Vlasenko et al., 2020a), first of all, designing PLE requires finding out the types of activities that the teacher carries out, and, secondly, determination of those Web 2.0 tools that can make this activity full.

This article is *aimed* at the presentation of a Mathematics teacher's PLE model and description of Web 2.0 tools that support the teacher during their activities.

2 METHOD

Applying deductive content analysis of research papers (Couros, 2006; Kadle, 2010; Morrison, 2013; Quinn, 2009), the authors of the present paper concluded the necessity to structure PLE of University Mathematics teachers, based on the types of their activities. When singling out the types of such activities, the authors also took into consideration the survey results. The survey, which had 16 questions, was designed with the help of an open online service and uploaded to the platform "Higher school Mathematics teacher" (Vlasenko, 2019).

87 respondents were involved in the survey, of which 70% have more than 15 years of experience in higher education. 56.5% of respondents hold the position of associate professor, and 30.4% – professor. At the same time, 87% of respondents have a doctoral degree.

The questions were aimed at defining the awareness level of the academic staff about using Web-resources for various types of teaching activity (Vlasenko and Chumak, 2020):

1) arranging the learning process;
2) searching for information;
3) doing research, analysis, and statistical processing of the information;
4) doing the calculation;
5) publishing research papers;
6) publishing popular science materials;
7) designing presentations;
8) collaborating and communicating;
9) saving data.

We analyzed the data from the Web-resources Statcounter (gs.statcounter.com, 2020), Free Maths The Geek Page (thegeekpage.com, 2019), Top Tools for Personal & Professional Learning (www.toptools4learning.com, 2020), EmerginEdTech (Walsh, 2014), the blog eLearning industry (Pappas, 2013), where ranking of Web-tools takes place according to their demand, popularity, and spreading. This data allowed us to create a PLE model for higher school Mathematics teachers (figure 1) (Vlasenko et al., 2020a).

We offer a short review of Web 2.0 tools that can support the teacher's activities.

Arranging the learning process. Prometheus (courses.prometheus.org.ua, 2021), Coursera (www.coursera.org, 2021), edX (www.edx.org, 2021), LinkedIn Learning (www.linkedin.com, 2021), Khan Academy (khanacademy.org, 2021) help a teacher to choose the courses that will encourage the improvement of teaching subjects. The teacher can take such courses to enlarge their experience and get knowledge and skills that do not concern teaching. Moreover, they can recommend some courses to their students to ensure mixed learning of the subject. It is also important that choosing and taking most courses will encourage the improvement of teacher's training in a different language.

Searching for information. Google Search, Yahoo!, Yandex will help a teacher to find the necessary information to write a scientific article or prepare for the lesson. The teacher can find and select for acquaintance and analysis some modern scientific articles on different subjects in peer-reviewed European and American online journals using, for instance, the service Google Scholar. The fact that search is supported in documents of different formats allows the teacher to learn how to work with such formats as PDF, RTF, PostScript, Microsoft Word, Microsoft Excel, Microsoft PowerPoint. Also, for instance, Google Maps allows the teacher to find the locations necessary for work. Editing these locations enables the creation of interactive tasks for students.

Doing research, analysis, and statistical processing of the information. The teacher will be glad to software and cloud calculations for carrying out researches, analysis and statistical information processing. A full set of business and scientific graphics of software STADIA, MS Excel will allow the Mathematics teacher to visualize the results of solving problems by graphic illustrations. Using MATLAB the teacher can organize the visualization of research data through building 3D graphics and the creation of animated videos and demonstrate them to students while teaching a subject. More than 250 statistical functions of the pack STATISTICA the teacher can use to carry out statistical research of any complexity to show the results of their scientific researches. Using SYSTAT and QtiPlot the teacher can represent analytical information of reports in form of graphics, conduct parametric and non-parametric data analysis. Also, the teacher can offer this software to students to carry out statistical information processing in course and diploma projects.

Doing the calculation. The systems of computer Mathematics MATLAB, Maple, MathCAD and online calculators Math Editor, Cantor, KAlgebra allow optimizing the solution of many mathematical problems. Mathematics teachers' use of these programs in their professional activities allow using a complex mathematical machine without learning algorithms at the professional level, in particular, while training specialists in engineering, and during the implementation of a project method while learning Mathematics (Bobyliev and Vihrova, 2021). Modern systems of computer Mathematics that are equipped with text editors allow teachers to use them while preparing scientific publications.

Publishing popular scientific materials. The presentation of your achievements is the most common type of activity among Internet users all over the world. The teacher can post video lessons, video lectures, practical classes using the platforms YouTube, and TED Talks. Teachers can popularize their experience having a personal blog on Blogger, in Google applications or mathematical pages on Instagram.

Publishing research papers. Using Open Science in Ukraine (openscience.in.ua, 2021) helps the teacher, would-be scientist, postgraduate students, and Master students to find sites with the list of specialized editions of Ukraine and Ukrainian editions that are indexed in Scopus and Web of Science. If the teacher has publications in the editions that are indexed in Scopus and Web of Sci-

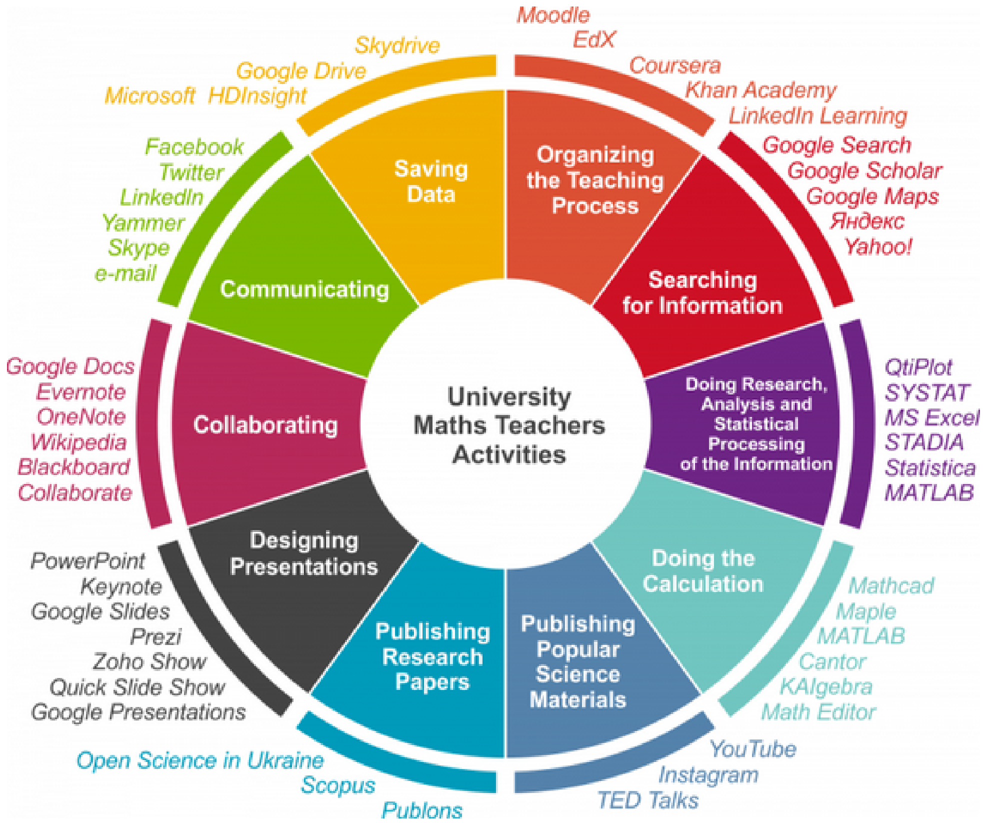

Figure 1: PLE model of University Mathematics teachers.

ence, then the registration in the world database Scopus (www.scopus.com, 2021) and database Publons (publons.com, 2021) will allow the teacher to get a h-index in Scopus and h-index in Web of Science, accordingly. Being registered in Google Scholar the teacher can monitor the citation of their publications in the editions of another level. Having a personal identifier ORCID iD (orcid.org, 2021) the teacher identifies himself / herself as a scientist and author of researches. The identifier ORCID iD guarantees the scientist: correct citation of their articles, the possibility to publish articles in prestigious international scientific editions, possibility to form a personal rating in Ukrainian scientific citation index, a possibility to take part in international ratings, a possibility to apply for grants.

Designing presentations. The teacher's learning of at least one of the programs PowerPoint, Keynote, Google Slides, Prezi, Quick Slide Show, Zoho Show, Google Presentation to work out stream presentations will allow supporting a speech with a presentation to visualize materials of a lecture or a practical class. The presentation and its demonstration to students especially during online education encourage a more efficient understanding of the material presented by the teacher.

Collaboration. Learning such tools as CoCalc, Google Drive, Evernote, OneNote, Blackboard Collaborate, Wikipedia will allow the teacher to create notes, have an event calendar, discuss new ideas with colleagues, use possibilities of common document editing by several users, organize communication with students (Popel et al., 2017).

Communication. Services of online communication such as Facebook, Twitter, LinkedIn, Yammer, e-mail, Skype are better in the teacher's communication with colleagues and students. Using the service Zoom will allow the teacher to hold classes in form of video conferences and online meetings with colleagues and students. Using WhatsApp allows users an immediate exchange of text messages via voice and video connection.

Storing data. Services Microsoft HDInsight, Skydrive, Google Drive, Dropbox will help the teacher to organize efficiently data storing. The use of these services enables the teacher to store files in the cloud, synchronize on several devices, easily exchange big files, and cooperate using them with colleagues and students.

3 RESULTS

Creating a selection of Web-tools that support the teacher's activities we considered the respondents' answers to the survey questions.

From the offered types of activities of a higher school teacher's PLE model, the respondents consider the organization of learning activities the most important (78.3% of respondents). The second place is given to such types of activities as carrying out researches, analysis, and statistical information processing, and publication of scientific materials. Cooperation is in the third place (60.9%), and the fourth is given to communication (52.2%).

Let's show the division of teachers' opinions regarding the use of Web-tools according to the types of their activities.

To the question: what tools for the organization of learning activities do you use most often – the respondent in 80.4% of cases answered Moodle, the platform Coursera took the second place – 23.9% (figure 2).

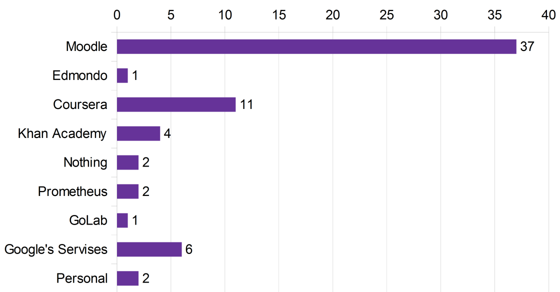

Figure 2: Tools for the organization of learning activities.

Google is most often used during the searching activities – 89.1% (figure 3).

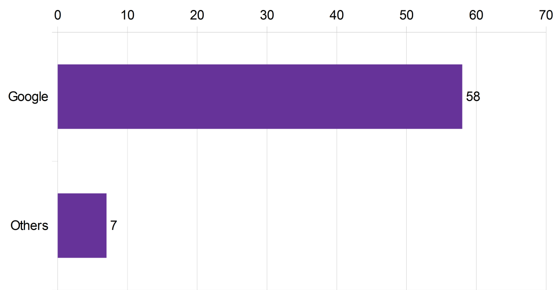

Figure 3: Tools for searching activities.

In order to carry out research, analysis, and statistical information processing respondents use different software, in particular, 87% choose QtiPlot, Statistica, StatGraphics, SYSTAT, MS Excel, STADIA; 21.7% mainly use online-calculators (figure 4).

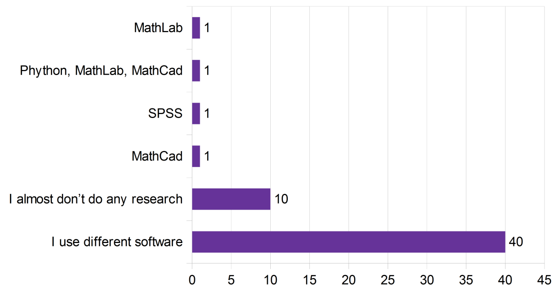

Figure 4: Tools to carry out research, analysis, and statistical information processing.

In order to carry out calculations, 73.9% of respondents use different software such as MathCad, Maple, MATLAB, Cantor, KAlgebra, Mathomatic, Scilab, Maxima, Octave, FreeCAD, PythonCAD, QCAD, Varkon, Linuxcad, Varicad, Cycas, Tomcad, Thancad, Fandango, Lignumcad (figure 5).

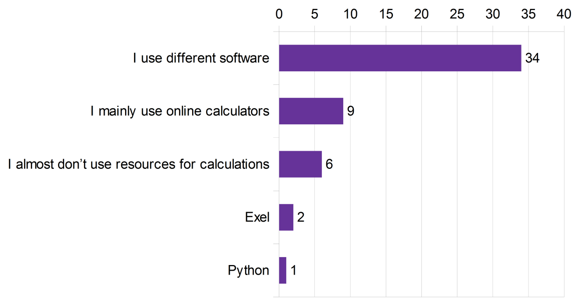

Figure 5: Calculation tools.

More than half of respondents don't use any tools for publishing scientific–popular materials; others prefer YouTube (21.7%) (figure 6).

95.7% of the participants publish scientific articles in specialized publications, 80.4% publish in publications indexed in Scopus and Web of Science; 89.1% of the respondents participate in conferences and publish theses (figure 7).

80% of the teachers choose PowerPoint among the tools to create presentations of speeches and materials, only 31.1% of the participants search for its alter-

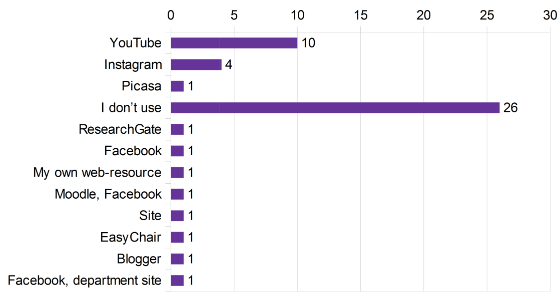

Figure 6: Tools for publishing scientific-popular materials.

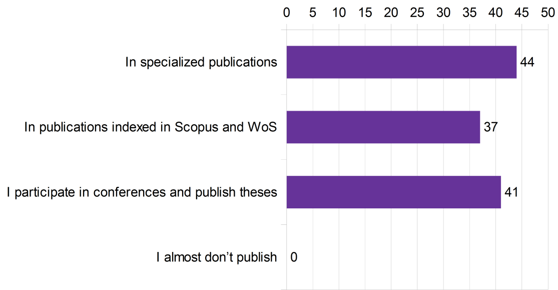

Figure 7: Publication level for publishing scientific articles.

natives (figure 8). 67.4% of the teachers use Google Docs for cooperation, notes, common work over the documents (figure 9). 93.5% of the surveyed teachers use email for communication, 89.3 % of respondents use communication tools messages WhatsApp, Viber 80.4% of respondents use Facebook (figure 10).

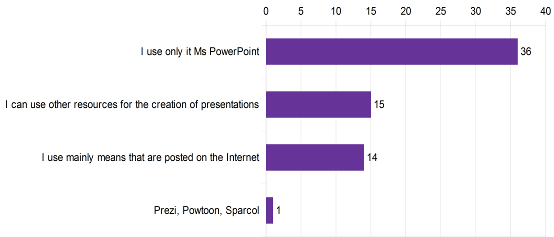

Figure 8: Tools for creating presentations.

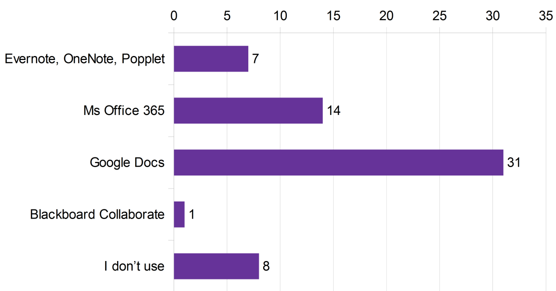

Figure 9: Tools for cooperation organization.

Google Drive is popular for storing data among the majority of respondents (84.8%) (figure 11).

Thus, this survey has shown that university Mathematics teachers are not knowledgeable enough in using PLE tools for different types of activities. In most cases, teachers use the same means for years. It is also proved by the fact that 39.1% of the respondents agreed to take a test according to the program "Survey of Adult Skills" (PIAAC, 2019) that assesses adults' knowledge in key skills of processing information, in particular, the use of their skills at home, at work and in public (figure 12).

The survey shows that university Mathematics teachers require support in using PLE tools for different types of activities.

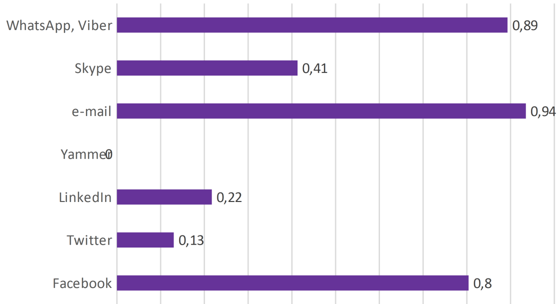

Figure 10: Communication tools.

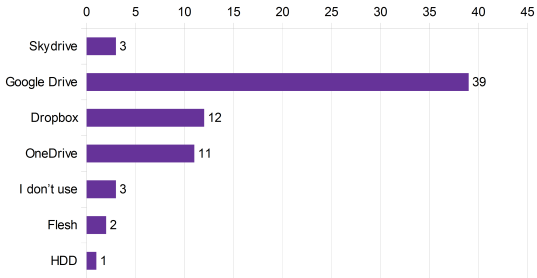

Figure 11: Tools for storing data.

4 DISCUSSION

Identifying the activities of University Mathematics teachers, the researchers in this study also consider the opinions of Shaikh and Khoja (Shaikh and Khoja, 2012), who believe that the teacher's professional activity is so various, as it comprises a lot of roles, for instance, Instructive Role, Cognitive Role, Designing Role, Planning Role, Social Role, Managerial Role.

Analyzing the results of (Yadav and Patwardhan, 2016; Bennett et al., 2012; Perikos et al., 2015), as well as responses of Ukrainian University Mathematics teachers, the authors of this paper concluded the deficient level of awareness of Ukrainian University Mathematics teachers about Web 2.0 tools usage.

Taking into account the conclusions of the (Tautkevičienė and Dubosas, 2014; Scherer Bassani and Ferrari Barbosa, 2018) about the limited involvement of Web 2.0 tools by teachers, we completely agree with Alhassan (Alhassan, 2017) that teachers' acquaintance with the involvement of technical tools to create educational content for its integration to pages of online courses has to be carried out gradually. The research by Yadav and Patwardhan (Yadav and Patwardhan, 2016) has proved our idea about the necessity to carry out a theoretical analysis of the technical capabilities of Web 2.0 technology, the use

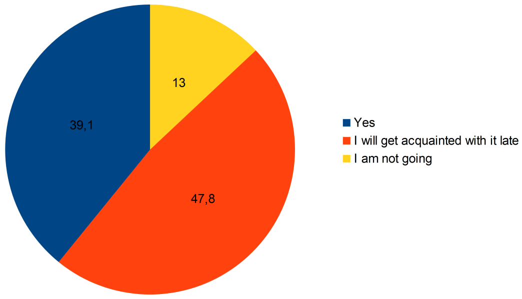

Figure 12: Teachers' distribution according to their agreement to take a PIAAC test (in%).

of which can interest teachers.

Ranking Web 2.0 services and their distribution following the types of activities carried out by a Mathematics teacher ensures the development of a useful personal environment that will enable the teacher to use different learning strategies and technologies during students' training. Searching for a solution to this problem, Perikos et al. (Perikos et al., 2015) proposed developing online courses for non-formal teachers' education. The idea of developing online courses aligns with the conclusions by Lovianova et al. (Lovianova et al., 2020) that studied the matter of developing online courses.

5 CONCLUSIONS

The analysis of the resources and research papers supported the assumption, made by the authors of the present study concerning the necessity to use a wide range of Web 2.0 tools for carrying out various types of activities by teachers and students. Relevance and timeliness of designing a PLE model of a University Mathematics teacher result from specificities of a Mathematics teacher's professional activities, and from the necessity to constantly improve their ability to use new resources.

Using deductive content analysis and taking into consideration the results of the survey, conducted among the Ukrainian teachers made it possible to identify the types of activities carried out by a University Mathematics teacher. With the help of the inductive content analysis method, the authors of the present paper processed the data on ranking Web-tools by demand, popularity, and prevalence. The respondents' answers to the survey questions and identifying awareness of Ukrainian teachers about the use of Web-resources for each type of activity became determining in designing a PLE model.

The authors of the present study are concerned that the solution to this problem lies in developing an online course for University Mathematics teachers to show them the advantages of using a personal e-learning environment and methods for designing it. The course can also be used by Master students majoring in Mathematics and all those who are interested in designing a personal e-learning environment.

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Digital and ICT Literacy Skills as One of the Key Competences of Future Foreign Language Teachers

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Keywords: Digital and ICT Literacy Skills, Educational Programmes, Educational Components, Future Foreign Language Teachers, Action Research, Comparative Analysis.

Abstract: The aims of this paper are to share the results of the action research of the future foreign language teachers' digital and ICT literacy skills development and to demonstrate the opportunities for their development while pre-service teacher training process with the focus on the courses of Methodology of foreign language teaching and Practical course of foreign language as well as other positive practices. The authors present the results of comparative analysis of Ukrainian and American educational programmes for future foreign language teachers as for their opportunities to develop their digital and ICT literacy skills. The article discusses the digital and ICT literacy skills use in learning and teaching as an important component of future teachers' training and a contribution to the university education quality and the employability of university graduates. The projects which influenced the action research elaborating are described. The results of three surveys are presented. The post-action-research stage is described as the one influenced with students' and teachers' participation in projects alongside with the extremely increased use of ICT in the conditions of the pandemic.

1 INTRODUCTION

The profession of a teacher is full of challenges and unpredictable situations. In spite of the teacher's specialisation there is a set of skills and competences equally important for high quality teaching and learning. Experienced teachers mostly get used to any unexpected circumstances in professional environment. However, the year of 2020, shortly characterised as the triumph of pandemic, made them facing quite new challenge – online teaching (Tkachuk et al., 2021). Under those conditions novice teachers seemed to feel more confident as being the so-called "digital natives", while their ability to build rapport in digital environment did not quite correlate with today's learners' demands.

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While the students obtain their higher pedagogical education, the reality changes and they take risk to acquire the out-of-date model of professional competence and strategy of teaching. It is a challenge to find the way out of this situation. Future teachers can and should be taught to develop their own professional thinking, awareness and skills and constantly be in their continuing professional development.

In the Decree of the President of Ukraine "On the Aims of Sustainable Development of Ukraine within the Period till 2030", it is pointed that to promote the national interests of our country, the diverse and equitable quality education and opportunities for life-long learning should be provided for all Ukrainian people (President of Ukraine, 2019).

Digital and ICT literacy skills are among the most important 21st century skills without which the modern teacher will not be able to provide effective teaching and cater for students' learning under the conditions of continuing innovation and modernisation of education irrespectively of its level (pre-school, pri-

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mary, secondary, high school, vocational, pre-higher and higher education) or type (formal, informal). They are especially important for the employability of university graduates and their successful professional activity.

Almost 20 years ago, in a planning guide presented with UNESCO it was stated that "with the emerging new technologies, the teaching profession is evolving from an emphasis on teacher-centred, lecture-based instruction to student-centred, interactive learning environments. Designing and implementing successful ICT-enabled teacher education programmes is the key to fundamental, wide-ranging educational reforms" (Khvilon and Patru, 2002). In this direction UNESCO continues its contribution to society's digital and ICT literacy skills development.

Compared to the UNESCO document of 2002, in 2016 the terminology such as 'the ICT competencies' changed to 'digital and ICT literacy skills'. In "EU commission (Skills panorama)" the term "digital competences" or "ICT Skills/digital competences" involves "confident and critical use of information society technology (ICT) in the general population and provide the necessary context (i.e. the knowledge, skills and attitudes) for working, living and learning in the knowledge society. Digital competences are defined as the ability to access digital media and ICT, to understand and critically evaluate different aspects of digital media and media contents and to communicate effectively in a variety of ICT influenced contexts" (Law et al., 2018). Thus, we can watch how the rapid development of digital technologies influences the essence of relevant skills and competences and promotes innovations in the system of higher education.

Daily digital discoveries and inventions, combined with the necessity of education adaptation to pandemic conditions, promoted blended and distance learning/teaching, favoured to learners' and teachers' deep diving into digital reality. The educational institutions of all levels developed their own strategies of making education accessible to their learners. In higher pedagogical education it is important to develop the strategies of effective university learning / teaching under the new conditions as well as training future teachers for being ready to act professionally in a changeable pedagogical environment, containing unpredictable or force-major situations.

The *aims* of this paper are to study the opportunities for digital and ICT literacy skills development while pre-service teacher training. The focus is on the experience of Ukrainian universities and their educational programmes for future foreign language teachers.

2 METHODS

The methodology of our research is presented with the procedure of action research.

The action research contained several stages according to the procedure of Chen (Chen, 2015):

- identifying problem of meaning (starting point, kick off, notice, find interesting area, etc.);
- developing questions and examine assumptions (reflect and formulate questions);
- planning (choosing enquiry strategies, ways of gathering data, planning interventions);
- taking action (intervening);
- gathering data (wider evidence);
- analysing data (reflecting on wider evidence, qualitative analysis);
- interpreting data (assessing impact on teaching and learning);
- reporting (formulating recommendations);
- taking action (wider scale intervention).

Besides of the mentioned above stages and their specifications we added comparative analysis of the data and before taking an action we planned implementing new elements into educational process. After having taken the action we compared the expected programme results formation with the previous ones.

The issues of future foreign language teachers' pre-service training are rather well-studied, though there still are the aspects which have not been paid enough attention. Such an issue is the one associated with skills of handling with information and communication technologies. So, we have studied Ukrainian and foreign experience of the future foreign language teachers' digital and ICT literacy skills development.

The next stage of our research was the study which helped us to collect the data about Ukrainian and foreign university educational programmes for bachelors and identifying their potential as for digital and ICT literacy skills formation.

This study was aimed at answering the research question:

1. What are the programme opportunities for the formation of students' digital and ICT literacy skills?
2. How do these components contribute to future teachers' digital and ICT literacy skills development?
3. What are the most effective ways to train digitally and ICT aware teacher of foreign language?

Our analysis comprised the analysis of all components of educational programmes giving the necessary information and qualitative data of the competences to be developed and the expected results as well as educational components contributing to their achievement. Ukrainian and American programmes were compared with the educational programme for future teachers of English implemented in Bogdan Khmelnitsky Melitopol State Pedagogical University.

The stage of interpreting data was realised by means of assessing impact of the educational programme content on teaching and learning. It was studied as the dynamic system of educational components, extracurricular activities, continuing process of amending and renovation of the content, methods, forms, means, modes and approaches to teaching and learning. The results of the tailor-made course "Information and Communication Technologies in Learning and Teaching" implementing were analysed together with other components of the educational programme. This course was especially valuable as a part of the course "Methodology of English Language Teaching", which proved to have the effective combination of content, modes of interaction, motivation and outcomes.

Taking action, in this case is sharing the results of all the previous stages of our action research as the positive practice of creating the student-centred educational environment with the focus on development of future teachers' 21st century skills. To prove that the educational programme under consideration could really enhance the technologies impact in the classroom taught by its graduates, we analysed and interpreted the data gained from its content and from responses of students, teachers and graduates about learning and teaching within its functioning.

3 RESULTS AND DISCUSSION

Each year university education becomes less accessible as the requirements for the matriculation are changing and becoming stricter. The quality of university education is now under profound renovation as, on the one hand, the Ministry of Science and Education emphasizes on high quality specialists' training based on modern demands and world standards; on the other hand, the National Agency for Higher Education Quality Assurance crucially has changed the procedure of accreditation of educational programmes and subsequently the criteria for their evaluation. Besides of quite reasonable and expected conditions for continuing change of higher education, there is one more unpredictable and sudden factor challenging its functioning such as the pandemic.

Nowadays most of educational programmes in Ukraine are renovated annually. The head of educational programme together with its staff have to analyse all stakeholders' needs and improve it in accordance with them. The authors of the article while being the heads of educational programmes for future teachers of foreign languages have decided to study the opportunities for digital and ICT literacy skills development while pre-service teacher training within their educational programmes. The comparative analysis with the focus on the experience of Ukrainian and foreign universities and their educational programmes has been realized.

It goes without saying that the study of existing experience and positive practices was based not on the educational programmes content only, but also on its dissemination in scientific and methodological resources. During our work with relevant researches we have discovered that in spite of the numerous works revealing the importance of digital and ICT literacy skills for any teacher, great advantages of ICT used in the process of learning and teaching foreign languages, the issue of digital and ICT literacy skills development as one of the key components in future foreign language teachers training have not been thoroughly investigated yet.

Diving into the topic of our study it would be relevant to mention Gavin Dudeney's recollections of his being a student in 1970s-1980s and understanding of literacy and numeracy as the 'three Rs' (reading, (w)riting and (a)rithmetic). He states that "times have changed, and the notion of 'literacy' in the wired world of 2014 is a completely different beast" (Dudeney, 2016). The researcher with co-authors Nicky Hockly and Mark Pegrum have created a taxonomy of the new digital literacies "by breaking them down into four main areas: those with a focus on language, on connections, on information, and on (re)design" (Dudeney, 2016). A focus on language is specified with print and texting literacies, mobile, gaming, hypertext, code; a focus on connections – with personal, participatory, network and intercultural literacies; a focus on information – with search, information and tagging literacies; a focus on (re)design is associated with remix literacy. Speaking about incorporating a focus on both digital literacy and 21st century skills into a language class, Dudeney (Dudeney, 2018) emphasises ensuring the learners acquire an integrated level of proficiency with technology, digital literacy and 21st century skills, which should be of benefit both in further study, and in professional contexts.

Houcine (Houcine, 2011) presented a "language training centre" in an Algerian university where ICTs are an integral part of the teaching practices and described its positive effect on learning and teaching foreign languages with such benefits:

- students develop better listening skills due to regular exposure to audio materials (audio and video recordings – authentic and software, podcasts, pronunciation software);
- selection of updated articles from the Internet contributes to learners' awareness of the language (grammar skills, coherence in committing ideas, syntax...) and of the specific scientific editing/presentation (scientific texts, reports);
- teachers reported on their learners being engaged, motivated and attentive;
- ICT impacted positively on students' proficiency. A majority of students got better scores in their fields after attending language courses at the MLC;
- students increased their ability to take notes effectively; i.e., they were more likely to listen to the teacher and grasp the message, select the appropriate information and take notes that will be further exploited;
- the enhancement of linguistic competence combined with motivation and challenge led to more autonomy and initiative (to do research on the Web, to propose links, to use online dictionaries and encyclopaedias).

The research presented by Hadef (Hadef, 2020) describes the survey conducted in the department of foreign languages with 30 students whose age ranges between 18–22 years old and 4 university teachers to assess the application of ICTs in the teaching and learning process. Students' and teachers' attitudes to ICTs application were studied and the following recommendations articulated: "University/school have to prepare to a digital society; develop a policy based on its own vision; make use of more digital tools; provide sufficient material; provide an academic training for teachers on how to use ICT's in teaching; prepare an equipped rooms; use video Conferences to present lectures" (Hadef, 2020).

One of the most relevant studies of the issue is revealed by Guillén-Gámez et al. (Guillén-Gámez et al., 2019) whose work has demonstrated that "future foreign language teachers have a medium-low development of pedagogical digital competence. The result of this is that technologies are still not being used today for pedagogical purposes. The lack of pedagogical use may be due to the fact that the teaching staff do not have a solid initial pedagogical training with regard to the development of digital competence, which implies their limited use of ICT, as well as their tendency to only use the best known tools on the market" (Guillén-Gámez et al., 2019). The researchers discovered that future teachers have an adequate motivation to use ICT, though there is still a lack of pedagogical consistency in their use, so they recommend educational institutions to motivate teachers by revealing benefits of using ICT.

Sevcikova (Sevcikova, 2016) explored her students' responses to digital technology and its practical use for teaching purposes while TEFL training. Her action research took place in Saudi Arabia. The teacher-researcher discovered that her students believed that "technology is essential for the future; it enhances learning and teaching, supports collaboration and motivation. They also pointed out some limitations such as IT literacy, the time-consuming nature of technology, and the lack of access to free internet learning/teaching resources" (Sevcikova, 2016).

It's crucial that there are specially designed courses for practising classroom teachers which can be used for future teachers. Such course is presented with Nik Peachey – the Blended Learning in ELT course. It is aimed at "developing teachers' understanding of the potential of blended learning for the development of English language skills" (Tomlinson and Whittaker, 2013). In spite of the fact that this course is tutored online the researcher's recommendations are of great use while improving university educational programmes for future teachers.

One more practical and useful research has been elaborated by Courts and Tucker (Courts and Tucker, 2012) as they suggest multimedia items that can be easily implemented in the college classroom such as animation, slideshows, blogging, instant messaging, podcasting, and video on demand. The researchers state: "As new technologies emerge, both students and educators are often eager to find methods of assimilating these technologies in their college classroom experience" (Courts and Tucker, 2012). Integrating multimedia in the classroom can allow students to apply real-world skills, learn effective collaboration techniques, learn creative ways of expressing their ideas, and synthesize complex content (Shank, 2005). Though the research dates back to 2012 its results can be used and positively influence learning and teaching in Ukraine even now.

Simultaneously with the analysis revealed in theoretical sources we paid our attention to the content of educational programmes for future teachers of foreign languages in Ukraine and in the US. So, under our consideration there were the educational programmes of Ball State University (USA), New York University (USA), Miami University (USA), Stony

Brook University (USA), Izmail State University of Humanities (Ukraine), Volodymyr Hnatiuk Ternopil National Pedagogic University (Ukraine), Pavlo Tychyna Uman State Pedagogic University (Ukraine), Vasyl Stephanyk Pre-Carpathian National University (Ukraine) and Bogdan Khmelnitsky Melitopol State Pedagogical University (Ukraine).

The objects of our investigation within educational programmes were competences and results of learning correlated with educational components as for their potential for digital and ICT literacy skills development.

We found out that there are essential differences between Ukrainian and American programmes as the approaches to developing the programmes content differ. In Ukraine the focus is usually on the ICT issues closely related to core subjects, i.e. to Pedagogy and Methodology of foreign language teaching. In American programmes besides of the same educational components there could be found much more variety of subjects.

In Ukrainian programmes the expected results are associated with the creation of educational-methodological means and equipment and application; search, systematising, analysis and check of the information; creation of educational environment.

American programmes for future teachers of foreign languages contain components which help them to master technological approaches and meet the challenge of integrating technology with the teaching of foreign languages as well as allow them to get much deeper knowledge of ICT and dive into the digital world. There are such subjects as Introduction to Business with Integrated Computer Applications, Computer Apps for Design, Computer Applications in Graphic Arts, Technical Design Graphics, Computers and Society, Learning and Teaching with Emerging Technologies, Software Engineering (service), Space and Place in Human Communication, The Internet and Contemporary Art, etc. As we can see, there is no limitation associated with the future professional skills necessary in foreign language classrooms only. Foreign language teachers can freely choose the subjects which will significantly broaden their worldview and the system of competences.

The need for changes in the system of Ukrainian higher education launched the projects aimed at its modernisation and quality improvement. As Ukraine tries to be in line with European and world standards, international organisations help it to reform all levels of educational system. Recently the reform of preschool education has just began, the UK Government and British Good Governance Fund support it; New Ukrainian School Concept is based on (ec.europa.eu, 2018); Ministry of Foreign Affairs of Finland supports this reform financially; The Lego Foundation contributes to the development of Ukrainian primary school.

As for higher education it is actively supported with the British Council and the British Embassy, America House, IREX and the US Embassy, Goethe-Institute and the Germany Embassy. For the last five years the most crucial in the sphere of teacher training were two projects implemented by British Council and Goethe-Institute.

Goethe-Institute project "Deutsch Lehren Lernen" (www.goethe.de, 2019) presents a series of continuing programme of learning based on innovative didactic approach of action research and corresponds to the world quality standards of teacher training. The project system comprises the integration of methodology of language teaching and foreign language learning as two inseparable components of a future teacher's professional competence.

"Deutsch Lehren Lernen" suggests the tasks on systematic observation and reflection on pedagogical activity by means of German language video-lessons from three continents. As the follow-up activities, the students can participate in one-week on-line course moderated by mentors. On accomplishing the course the students are to do the planning and elaborate their own action research project.

The project activity is based on blended learning and combines traditional language learning with digital learning, i.e. doing on-line tasks, new words and patterns revision and use, virtual collaboration with group-mates, virtual class learning, Adobe Connect webinars for both students and teachers with the system of completed tasks monitoring.

There are such effective learning tools as Page Player-App, E-book, introductory on-line test (Einstufungstest online), media-pack, help-test (Testhelf), application for the work with vocabulary (Vokabeltrainer - App), supplementary on-line materials, bilingual glossary. The advantage of the project course is obvious as it promotes and motivates students' learning and helps teachers to deliver their teaching taking into consideration all challenges of modern education and information and communication technologies development.

The project "New Generation School Teacher" (www.britishcouncil.org.ua, 2019) was initiated by British Council Ukraine and the Ministry of Education and Science of Ukraine in 2013. It aimed at introducing change to the initial teacher education system in Ukraine. The project resulted with the PRESETT curriculum in Methodology and the network of Ukrainian universities implementing it and proving its effectiveness. The project outcomes were presented with such learning ones as:

- student-teachers' and newly-qualified teachers' English proficiency is improved;
- their classroom skills and confidence are enhanced;
- their digital and social media skills are developed.

On the level of action outcomes the newly-qualified teachers:

- teach more effectively and confidently;
- engage with colleagues;
- join networks and meet colleagues overseas;
- can integrate ICT in/outside the classroom;
- are committed to CPD.

As it can be seen the ICT skills were paid special attention and there was designed a separate unit of the new Methodology course "ICT in Learning and Teaching". Its objectives are to form the students' awareness of the advantages and disadvantages of doing activities on a computer and other electronic devices as opposed to similar paper-based activities; the criteria for evaluating and selecting online resources for language teaching purposes; and to develop their skills to use different software (e.g. Microsoft Word, PowerPoint) for language learning and teaching purposes; make use of social networking sites, blogs, wikis, etc. in language teaching; evaluate the potential of online audio and video for language teaching purposes; assess possible risks of using the Internet with young learners and develop a set of rules for cyber safety; explore current trends in mobile learning and be able to use mobile phones for teaching and learning reference.

The whole project represents the large-scale research which comprised 8 university at its beginning, and 13 universities and colleges within the period of its piloting. Our small-scale research was based in its results but was elaborated on the content prepared and piloted in Bogdan Khmelnitsky Melitopol State Pedagogical University only.

Besides of "New Generation School Teacher" project results we used the experience of our participation in the joint project of International Research and Exchanges Board, Academy of Ukrainian Press and Ministry of Education and Science of Ukraine "Learn to Discern: Info-Media Literacy" as its realisation is concerned around integrating info-media focused modules or courses into pre-service teacher training syllabus. In spite of the fact that the project is mostly oriented at the training of teachers of Ukrainian Language and Literature, History and Arts, we have implemented its element in our courses for future teachers of foreign languages.

The amended and modernised curricula of Methodology of Foreign Language Teaching and The First Foreign Language develop teacher profile specialty-based competences as well as critical thinking skills, implement interactive methods of learning and teaching, dialogue modes of interaction, and the ample use of online tools.

While identifying the issue for doing our action research we studied the experience presented in scientific-methodological resources and found out the challenges and opportunities for our learning and teaching context.

The role of information and communication technologies in higher education has been being studied since the very beginning of their appearance and application in this branch. The issue has its diachronic and space aspects, i.e. in different periods we observe the studies of various technologies and the context of national systems of education, types of educational institutions, technical and financial capability, and other numerous factors have an impact on the ICT use and their role.

It is obviously that the ICT use in higher education provides for both personal professional development and the world's information-digital-literate society. Modern education should be available for all people always and everywhere. That is why "lifelong learning has become the driving force to sustain in the contemporary competitive environment. Therefore to strengthen and / or advance this knowledge-driven growth, new technologies, skills and capabilities are needed" (Mondal and Mete, 2012).

The first overview of the issue helped with the starting point of our research and finding the relevant area. Still we had to specify the narrow aspects for elaborating and implementing. This was a cause for doing the survey. Our respondents were university students and school teachers. The questions asked were about their attitude to the use of ICT in class, their confidence in this practice, and their skills in handling with cyber well-being, websites and learning platforms choice, online resources use, social networking, blogs, wikis application, flipped teaching, proper use of various devices such as mobile phones, tablets, laptops, interactive whiteboards. There were 200 students and 30 teachers who took part in the survey.

In 10 months we repeated the survey of the same students and teachers. There were the crucial differences in educational environment between two surveys as the pandemic influenced greatly the role of ICT in classroom when each university teacher and student faced the challenge of completely distance education. In our case, one more factor made its impact on learning and teaching – it was participation in two projects "Learn to Discern: Information and Media Literacy" (continuing) and "Teaching Excellence Programme" by British Council, Advance HE, Institute of Higher Education NAES of Ukraine in partnership with Ministry of Education and Science of Ukraine and National Agency for Higher Education Quality Assurance in Ukraine (started in May, 2020), and participation in the Training for Teachers by Progresylni (August, 2020).

The project "Learn to Discern: Information and Media Literacy" contributed to the development of skills to work with information by means of various online tools and resources. The team of teachers and students of Bogdan Khmelnitsky Melitopol State Pedagogical University won the grant for the creation of the Hub of Infomedia-Literate Citizens. The team consisted of people who took part in both surveys and they surely demonstrated new results. Due to involving at least 300 people improved their handling with information online and Zoom platform for education and communication.

Application for participation in Teaching Excellence Programme was based on creation of Hub for Teaching Excellence Development. It has been recently created (in November, 2020) and several workshops for university teachers were delivered. Two of them were devoted to the use of ICT for student-centred education. Sharing the experience of participation in the Programme was of great value for the development of digital and ICT literacy skills of both teachers and students. The trainers from Advance Education (Great Britain) Kathy Wright and Caroline Brennan combined such issues as influences on learning, conceptions of learning, learning theories, outcomes led teaching, planning for learning, making teaching interactive, principles of assessment, types of assessment, giving and receiving feedback, reflective practice, action research, interdisciplinary and other issues with the advanced use of various modern technologies, resources and tools (Edmodo, Socrative, Thinglink, ClassDojo, Storybird, Animoto, Kahoot!, Scretch, Quizlet, Trello, Edpuzzle, Jamboard, TurnItIn, Canva, Schoology, AnswerGarden, Nearpod, Flipgrid and many others).

Besides of demonstrating and explaining all those technologies and resources, the trainers used the loop input, involving participants into activities realised by means of all those tools. Most of them were multifunctional and catered for achieving several educational purposes, while some of them helped to create rapport and demonstrated good sense of trainers' humour. Such simple use of Zoom as filters turned the trainer into a master, then deer and later on helped to create holiday frame. All those workshops-webinars made participants discover numerous ICT uses for education promotion under any circumstances.

The first survey allowed us to see the so-called "digital divide" as only two of teachers (6.7%) answered that they are completely confident as for ICT use in classroom. Completely confident students were 49%. Though, the questions about cyber well-being, websites and learning platforms choice, blogs and wikis application, understanding of flipped teaching demonstrated that there were some gaps in their information literacy and digital safety skills.

For teachers who took part in our survey we prepared a series of workshops to help them in ICT application in foreign language classrooms.

For students, on the basis of our baseline study we elaborated the unit "Information and Communication Technology (ICT) in Learning and Teaching English" (Goncharova and Konovalenko, 2019) which was based on blended learning and included the following items:

- Modern learning technologies and their relevance for the educational process.
- Cyber well-being: keeping children safe on the Internet.
- Selecting and evaluating websites for teaching and learning purposes.
- The use of learning platforms (e.g. Moodle) for teaching purposes.
- Using online audio and video resources for language learning and teaching purposes.
- Exploration of opportunities offered by social networking sites, blogs, wikis to language learning and teaching.
- The notion of a 'flipped' classroom and its benefits; traditional vs. flipped teaching.
- The main uses of IWBs (interactive whiteboards). and their benefits as opposed to traditional whiteboards.
- Exploration of opportunities offered by mobile devices (e.g. smartphone) in language learning.
- The use of different software and online tools for teaching and learning purposes.
- Power Point making rules.
- Effective ways of information search, finding the primary sources. Accumulating and generalising the information.
- The notions of copyright and plagiarism. Following the copyright. How to avoid plagiarism.

- Teacher's skills in photo, logo, symbols, posters, emoticons, memes, infographics use.

There were no traditional lectures within delivering this unit. The main modes of interaction were presented with games, jigsaw learning, buzz groups, socratic technique, role play, workshop, simulation, cross-over groups, guided reading, lecturette, brainstorming, speaking corners and others. Of all methodology units this one was of the greatest interest for students and positively influenced their motivation to learning. It was confirmed at each session which ended with taking students' feedback.

Each session began with studying the experience on the topic of it. Starting where the students are helped us to choose between possible variables and contributed to making the unit content and methodology of its deliverance more flexible.

Here there are some examples of organising the learning within the unit. In the session devoted to cyber-well-being, after getting acquainted with its principles, watching several videos and brainstorming all ideas about safe use of the Internet, the students make a list of rules for communicating in the world web. They work in groups and find the examples to each rule from the Internet. Each group creates a document on a Google Drive and then works with all lists created by other groups. They add other suggestions or comment on other groups' products. After discussing the rules of netiquette, one student takes a responsibility to make an accumulated netiquette code and shares it with all students.

One more example of work in teams is presented with evaluating the sites. Before doing this evaluation, the students learn the following criteria essence:

1. Audience
2. Credibility
3. Accuracy
4. Objectivity
5. Coverage
6. Currency
7. Aesthetic or visual appeal
8. Navigation
9. Accessibility

After that their teams work with different educational websites and evaluate the possibilities for their use in the narrow context, i.e. they are informed on the age of learners and their level of English.

When one team presents their findings the representatives of other ones ask questions and give comments. The activity is summarised with formulating tips for the work with websites.

The work with online courses was a little more time-consuming for students as they had to begin some courses (according to their learning interests) on various learning platforms such as https://futurelearn.com or https://openlearning.com. After diving into their courses and getting access to all platform tools, students analysed the content management, curriculum mapping and planning, ways of communication and management of the platform. On the stage of discussing the platforms the students are asked to reflect on their possible moderating such courses, strengths and weaknesses of them.

The use of social networks in learning and teaching arouse the most interest of students. This topic was studied with simultaneous revision of keeping children safe on the Internet. The students suggested the ways of possible algorithms of social media use for educational purposes. This way of ICT use was studied in micro-teaching as students prepared 1-2 activities for their group-mates playing the roles of school students. Through the prepared activities a student-teacher taught English or German to his/her school students. After each microteaching there was a feedback session aimed at finding positive features and methodological mistakes so that avoid them in real classroom.

Especially valuable for students was the work with wikis and blogs as they promote online writing which is rather important for teachers-philologists. In this case we asked students to create their own blogs. They worked in small groups and had one task per a group. To make use of the task they created the blogs of newly-qualified teachers so that they could use them while having their school experience (practice).

All above-mentioned examples were used in methodology class, though sometimes we applied activities of the same typology in our language classes. We give just one example of a task in the class where German is taught as the second foreign language.

So, the students got a set of QR-codes with the help of which they had to find the endings of the statements beginnings of which were given. Then they had to match parts of statements according to the logic approach

In practical language classes especially often were used mobile phones applications as they helped to work with vocabulary and grammar (visualising, training, revision, test control), listening. Writing skills were monitored on the level of messaging. Still for larger pieces of writing we used standard e-mail writing which helped students to learn to write various types of letters. Before writing such letters they searched the information necessary for that very kind of a letter.

While gathering data on our action research we looked for wider evidence of the unit effectiveness. That is why the same survey was conducted for the second time. It confirmed that most of students (87%) began to feel more confident as for ICT use in class. Besides, they were acquainted with a wide range of software, online tools, applications and other methodologically valuable ICT items. While speaking about students completely confident with ICT we discovered 67%. There were still a lot of students quite confident with the use of Instagram or TikTok and very unaware of how to use digital opportunities in their future professional activity.

The ICT use in learning and teaching unit was a very dynamic and useful for future teachers. Its importance and relevance was confirmed by students and teachers. It is the call of the time to make the classroom blended and to transfer a part of learning to virtual reality which so important for "digital native" school students. Besides, modern university students are ready to implement the ICT innovations.

The students had a good opportunity to train in using ICT in hands-on activities when they had their school experience (practice). So, their reflective journals they wrote while practice contained the same feedback as in the end of each methodology session: the ICT is a powerful methodological tool and the factor which favours learning and teaching stay effective.

After the third survey we discovered that the situation changed to the better as 6 teachers grew confident with ICT use in classroom (20%). They explained that fact with the need for vast ICT application during the pandemic and the direct dependence of their teaching on technological decisions. Participation in project events and workshops stimulated their progress as well.

The students stated their progress as well. The number of completely confident students grew up to 75%. The most frequent explanation for the progress was the same as the teachers' one – the emerging need for ICT use as the only way for their learning. Students shared their new experience as "up-scaling their digital worldview".

The comparative analysis of the contents of Ukrainian and American educational programmes demonstrated that the American ones give the students much better possibilities for the development of digital and ICT literacy skills, including both for their future teaching foreign languages and more advanced use. However, among Ukrainian programmes there were several under our consideration which proved to be rather progressive in this direction. They were the programmes of Ternopil, Uman and Melitopol universities. These three programmes were greatly influenced with participation in the project "New Generation School Teacher", so the educational components for digital and ICT literacy skills of future teachers of foreign languages appeared to be well represented. While having such positive experience of specific professional training there is the need for implementing some educational components aimed at advanced ICT use.

The application of ICT in both teacher training and those teachers' future professional activity can be considered unlimited as the technology is rapidly developing and changing the world around us as well as the educational opportunities. Virtual reality contains the enormous potential for improving the quality of learning and teaching foreign languages. This issue have been studied Symonenko et al. (Symonenko et al., 2020) who emphasized that "the practice of immersion into virtual environment in foreign language learning will enable students to feel themselves an integral part of the professionally oriented situation which is designed specifically to prepare the course participants for communication within" (Symonenko et al., 2020). Researchers point that virtual reality tasks help students to get used to "psychological challenges and apply existing speaking skills in a foreign language", "encourage spontaneity" and increases students' motivation to "achieve better results in a training course" (Symonenko et al., 2020). Virtual reality is especially valuable for teaching languages in the conditions of natural language speech environment. Besides of demonstrating "situational models of possible daily life circumstances for foreign language communication" (Symonenko et al., 2020), virtual reality based tasks surely promote the development of future teachers' information literacy and digital skills.

4 CONCLUSIONS

The results of our action research and the comparative analysis of American and Ukrainian educational programmes helped us to prove the importance of the future foreign language teachers' information literacy and digital safety skills development to our students and teachers. The prepared materials, chosen ways of teaching, possibility to apply all they got to know demonstrated to future teachers the opportunities for their development while pre-service teacher training process.

The elaborated unit implementing contributed to the development of future teachers' awareness of the advantages and disadvantages of ICT use in the classroom, the criteria for evaluating and selecting online resources and ICT software and applications for language teaching purposes, skills of using various software, social networking sites, blogs, wikis, online tools in language teaching, evaluating the potential of online audio, video and other visuals, assessing possible risks of using the Internet with learners and creating conditions for cyber safety, using various electronic devices justified for achieving educational aims.

Their methodology and language classes supplied future teachers with the set of professionally valuable awareness and skills which will encourage them to follow-up their journey from newly-qualified teacher to an experienced one who will be information literate and ready to create digitally-safe learning environment. This is one of the conditions for sustainable development of our country.

The analysis of educational programmes of Ukrainian and American universities demonstrated that in the latter there are much more opportunities for the development of digital and ICT literacy skills of future teachers of foreign languages in the terms of their specific activity and advanced use of ICT. In Ukraine the positive practice is observed in the universities participating in international projects which help to acquire the best examples of innovations in higher education. Three Ukrainian universities – Volodymyr Hnatiuk Ternopil National Pedagogic University, Pavlo Tychyna Uman State Pedagogic University, Bogdan Khmelnitsky Melitopol State Pedagogical University – have a good range of educational components designed for future teachers of foreign languages to develop their digital and ICT literacy skills. Among these three universities, Bogdan Khmelnitsky Melitopol State Pedagogical University has even more positive practices as its teachers and students are the participants of "Learn to Discern: Information and Media Literacy" project and Teaching Excellence Programme, which boosted the use of ICT in educational activity.

One more factor interpreted as a negative one all over the world has made a positive impact on the issue under our consideration. It is the COVID-19 pandemic as it made the university community to conquer the digital world and focus on ICT use in the virtual classroom. As 'practice makes perfect' most of teachers and students confirmed that they have improved their digital and ICT literacy skills since March, 2020.

There are still a lot of issues waiting for further study and finding solutions. For future teachers of foreign languages it would be a great opportunity to learn handling with the virtual reality with specific purposes in their professional area. Ability of producing digital content is one more urgent need for teachers of any subject. It is important for all modern teachers to become competent in information and communication technologies use as they are to accelerate human progress and work for its sustainable future by means of ensuring inclusive and equitable quality education for the youth.

Ukrainian educational programmes need amendments and adding the components aimed at the development of advanced digital and ICT literacy skills without any restrictions as for specialty.

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Implicit Potential of Immersive Technologies Implementation in the Educational Process at the Universities: World Experience

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Abstract: The article identifies the implicit potential of immersive technologies implementation in in the educational space of universities around the world. The content of basic research concepts has been determined. The advantages and disadvantages of using immersive technologies have been analyzed. The achievements of the world's universities have been clarified: the use of immersive technologies in the professional training of the future archaeologists to perform work on archaeological excavations has been reflected; in training architects and engineers for computer modeling of any of the most complex projects; in the training of the future pilots to guide the landing of aircraft on the aircraft carrier; in training rescuers to extinguish fires and rescue people; in the training of the future physicians for surgery or for experiments with hazardous chemicals. Emphasis is placed on the use of immersive technologies in the education of students with special educational needs to create inclusive learning environment, taking into account the needs and capabilities of each student. Based on the analysis of world experience in the use of immersive technologies in the educational space of universities, it was found that these technologies are used in the following areas: a) immersive learning technologies are actively used during distance learning, which allows, in particular during video conferencing to improve learning efficiency (University of British Columbia); b) to determine the level of empathy for the problem of homelessness, which allows to get the social experience of a person who becomes homeless (Central Pacific Institute in Hawaii); c) to study the effects of ocean oxidation on coral reefs, to provide knowledge about the environmental problem and to develop negative emotions in students about human activities that harm the beautiful and pristine ecosystem (Punahou International University). It is generalized that the use of immersive technologies in the educational space of universities of the world is used not only in the process of professional training for various sectors of the economy to gain professional competencies, but also to gain social, emotional experience and to actualize environmental issues.

1 INTRODUCTION

Educational systems around the world are under increasing pressure from society to introduce new infor-

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mation and communication technologies into the educational process to teach students the knowledge and skills they need in the 21st century. This involves the transformation of the educational process and the introduction of new learning technologies (Khvilon and Patru, 2002, p. 3). Education is the basis for sustainable development of society, so research and teaching staff are constantly looking for opportunities to improve the quality of education. In the age of digital technologies, one of the effective ways to improve the quality of education and the learning process is the use of computer technologies. Therefore, in our opinion, the use of immersive teaching methods is a natural next step in the evolution of education.

Problems of using immersive learning technologies are highlighted in (Babkin et al., 2021; Kovalchuk et al., 2020; Mintii and Soloviev, 2018; Shepiliev et al., 2021; Trach, 2017). In their scientific researches, AR & VR technologies as a method and means of teaching, as well as the features of the use of immersive technologies in the system of medical education have been studied.

In (Bakin, 2020; Lukashin, 2019; Kornilov and Popov, 2018) the interpretation of basic concepts has been done, some aspects of the theory and methods of using VR technology in the educational process have been shown, the features of the use of immersive technologies as a factor of educational development have been studied.

The questions of peculiarities of the use of immersive technologies have been studied by Khvilon and Patru (Khvilon and Patru, 2002) in order to study information and communication technologies in teacher training, by Bockholt (Bockholt, 2017) to determine the essence and features of virtual reality (VR), augmented reality (AR), mixed reality (MR). Biggs (Biggs, 2018) focuses on using the potential of VR technology to help memorize learning material. Calvert and Abadia (Calvert and Abadia, 2020) investigated the influence of immersion of university students and high school students in educational narratives using virtual reality technologies.

Analysis has shown that in some scientific researches (e.g., (Kamal et al., 2019)) the issue of the use of immersive technologies is studied on the example of universities: University of British Columbia, Central Pacific Institute in Hawaii, Punahou International University, Malaysian universities. It should be noted that these and similar studies have not yet covered the experience of using immersive learning technologies in the educational space of the university, taking into account the positive world experience. Unfortunately, there is no scientific research on the use of immersive learning technologies in the training of specialists in university through the prism of such a pedagogical field as comparative pedagogy.

The *aim* of the article is to analyse the theoretical aspects and practice of implementing immersive technologies in universities of the world.

Taking into account the complexity of the study of the state and prospects of development of the use of immersive technologies in the universities of the world in the context of our study requires addressing the following issues: forms, methods and means of using immersive technologies in leading countries of the world; analysis of positive and negative experiences in the implementation of immersive technologies of teaching students in the world's leading universities.

2 METHODS

Interrelated and complementary research methods have been used to achieve the aim of the scientific intelligence. Thus, to collect scientific material in the article the method of studying scientific sources, analysis of the results of surveys conducted by international companies has been used. In particular, a survey conducted by the global law firm Perkins Coie LLP and XR Association in 2019, which identified specific areas of use of immersive learning technologies in the training of professionals in the world's leading universities (www.perkinscoie.com, 2019). The results of the survey conducted by the company Sony in July 2019 on the use of video in higher education institutions were studied (Ruddock, 2019). The results of this survey give us the idea of how video is currently used in the educational space of universities, and what the use of video in the educational process may look like in the future; questionnaires and surveys conducted among researchers and students of Lviv Ivan Franko University, Volodymyr Hnatiuk Ternopil National Pedagogical University and Khmelnytskyi Humanitarian-Pedagogical Academy allowed to determine that respondents are familiar with virtual and augmented reality technologies in the context of their use for entertainment, games, but a clear definition of what is immersive learning technology could give only research and teaching staff, students answered that they do not know how to define such a concept, or difficult to answer; special linguistic methods allowed to make correct editing and translation of information from English.

3 RESULTS

The introduction of new innovative technologies in the educational process of universities is an integral part of improving the quality of education around the world. In connection with the global pandemic, although distance learning has been introduced in universities (Bobyliev and Vihrova, 2021), teaching is carried out mainly by traditional methods, which include providing material in the form of text documents, its processing by students and testing of knowledge (Kovalchuk et al., 2020, p. 159). Therefore, in this research we will summarize the world experience of using immersive learning technologies in the educational space of universities.

Let's consider the problem of development of immersive technologies. The idea of creating a virtual world originated in the 1930s and belongs to Stanley Grauman Weinbaum, who described a similar world in the story "Pygmalion's Spectacles" (Weinbaum, 1935). It was then that VR technologies began to develop, but due to technical limitations and high costs of ample opportunities, they were not actively introduced (Bakin, 2020, p. 17).

With the development of immersive technologies, educational processes become more complex and a grainy picture of reality emerges. There is a whole spectrum where the digital and real worlds are mixed and mixed reality is used, which is becoming increasingly important (Bonasio, 2019, p. 2).

A new impetus for the development of immersive technologies occurred in 2014, when Facebook acquired the startup Oculus VR – a pioneer of digital technology. An updated model of the virtual reality helmet was released, which caused a real sensation in the technology market. Nowadays, VR is gaining momentum and refers to the so-called immersive technologies – the generalized name of all technologies that include human interaction with space, information, content. They blur the boundaries between real and fictional worlds, allow to interact and immerse oneself in information and information product (Glazkova, 2019).

According to a survey conducted by the global law firm Perkins Coie LLP and the XR Association in 2019, by 2025, immersive technologies, including augmented reality, will be as necessary as mobile phones. This is the opinion of almost 9 out of 10 respondents who took part in the survey (www.perkinscoie.com, 2019, p. 2).

The use of immersive learning technologies in the educational space of higher education institutions provide the effect of full or partial presence in the alternative space and thus change the user experience in different fields and in different specialties.

The components of immersive learning technologies are virtual and augmented reality technologies, as well as 360° video. In our research it is necessary to clarify the meaning of immersive technologies and to show the difference between virtual and augmented reality technologies.

We are going to consider in more detail what lies behind the basic concepts of our research. Virtual reality is often used to denote an experience that completely immerses the user in the environment created by the computer, and largely "disables" his or her physical environment. Augmented reality, contrary, imposes digital elements on real objects and backgrounds.

Virtual reality is an ideal educational environment. Perception of the virtual model with a high degree of reliability allows to qualitatively and quickly train professionals in various specialties: aviation, process control, medicine, remote control of technical means and more. Over the last decade, virtual reality has become a leading technological trend in the development of educational technologies. This is due to the powerful investments of technology companies that improve VR systems, while increasing consumer access and interest in these technologies (Renganayagalu et al., 2021). Professional reality training allows to visually conduct lectures and seminars, workshops, demonstrate to learners all aspects of the real object or process, which in general gives a huge effect, improves the quality and speed of educational processes and reduces their cost (Trach, 2017, p. 313).

This is, first of all, visual and sound content, sound in this case of key importance – it complements the virtuality and creates the effect of presence in an unreal location by simulating the reflection and directions of sound waves. One can get into alternative, virtual reality, for example, wearing special glasses, dividing the picture in front of the eyes into two parts, they create a stereoscopic effect. In the presence of tracking for body positions, the virtual space will also take into account the movements of the head and torso.

There are other ways to get into virtual reality: a smartphone with a special VR application, tracking systems, special gloves, mobile VR helmets and more (Lukashin, 2019; Bockholt, 2017). We are going to consider them in more detail.

Smartphone with a special VR application, which is inserted into the case with lenses – Google Cardboard.

Tracking systems allow moving the user into the virtual space, and the costumes that convey feelings from virtual reality are also being worked out.

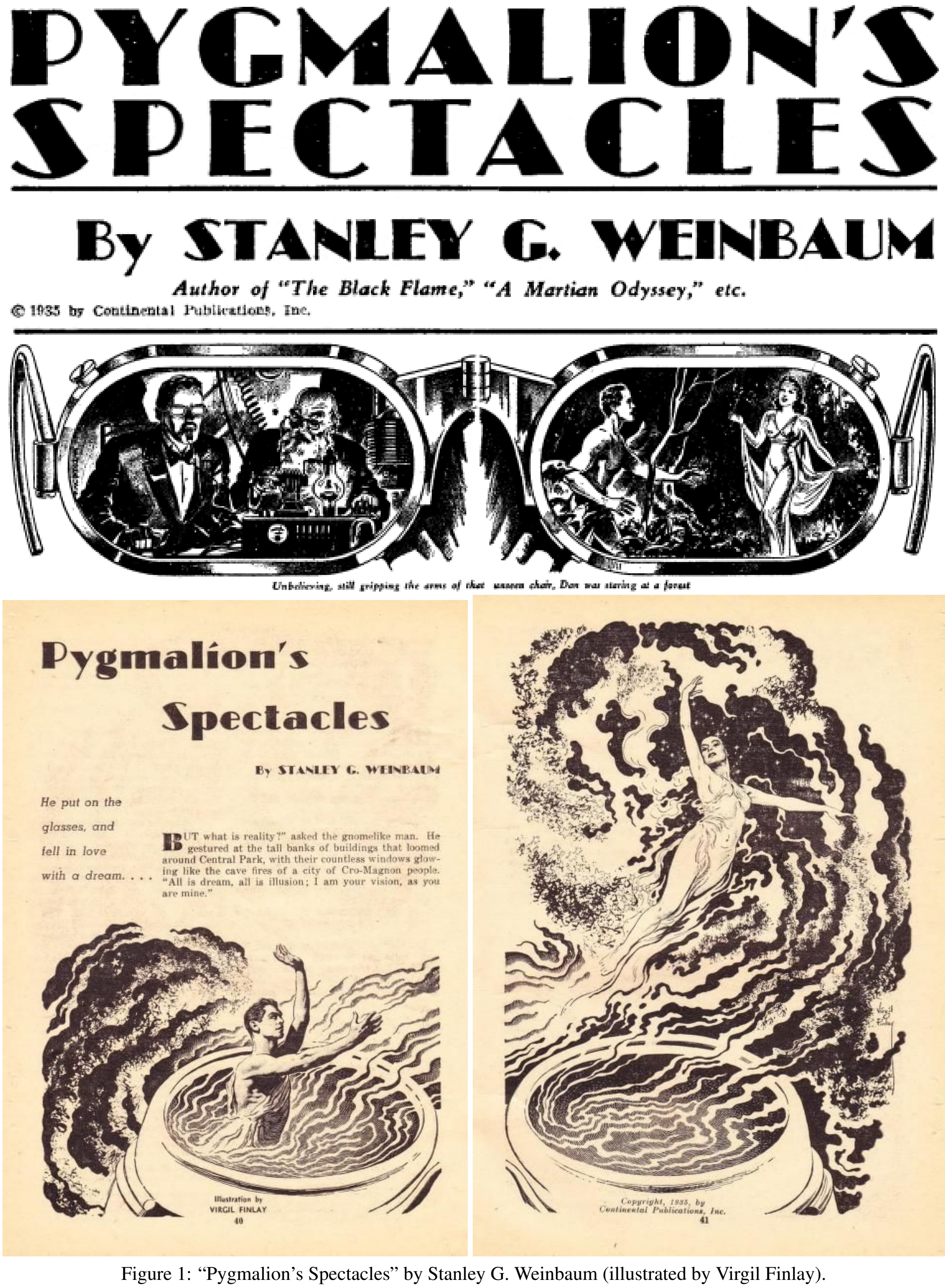

Figure 1: "Pygmalion's Spectacles" by Stanley G. Weinbaum (illustrated by Virgil Finlay).

Special gloves instead of the usual joystick, so that human hands naturally interact with the virtual world.

Mobile VR helmets with built-in monitors (HTC Vive, Oculus Go and others), optimized devices with high-quality graphics, integrated sound and joystick for control.

Standalone VR helmets (like Oculus Rift), graphics to which are transmitted via wires from a gaming computer with a powerful video card, communication with a PC creates restrictions on use, but VR helmets have better graphics and more potential purposes for users.

Trekking cameras capture the position of the joystick and the position of the person, immersing him or her in virtual reality more realistically, complete with helmets are controllers.

Augmented reality is the result of entering into the field of perception of any sensory data in order to supplement them about the environment and improve the perception of information.

The term "augmented reality" was proposed by company Boeing researchers (Tom Caudell) in 1990 (Caudell and Mizell, 1992). The concept of 1994 by Milgram and Kishino (Milgram and Kishino, 1994) defines augmented reality as part of a mixed reality, also called a hybrid reality. But since 2016, Microsoft has been actively using the term "mixed reality" to market its HoloLens product. And now some experts (and equipment suppliers) define the terms as follows:

Augmented Reality – projecting any digital information (images, videos, text, graphics, etc.) on top of the screen of any device. As a result, the real world is supplemented by artificial elements and new information. It can be implemented using applications for ordinary smartphones and tablets, augmented reality glasses, stationary screens, projection devices and other technologies (www.it.ua, 2018).

Augmented Reality technologies can create digital information (images, videos, text, graphics) on device screens and combine virtual objects with the real environment. For example, the game Pokemon GO is a prime example of AR technology (pokemongolive.com, 2021).

Panoramic and 360° photos or videos. These are sequential sets of pictures sewn by means of algorithms, it is possible to make them both by one camera, and special 360° cameras. Cameras which take pictures of surrounding space then the received videos are sewn up in special programs. There are also seamless solutions, but they are more expensive, sometimes additional graphics are added to the finished video. Nowadays, "panoramic" online broadcasts are also common, when you have several points with a panoramic view, which give the viewer the opportunity to "be present in the moment" (Lukashin, 2019).

Virtual reality, using a 360-degree image, carries a person into the artificial world, where the environment is completely changed. We can get acquainted with augmented reality only with the help of a smartphone, but to dive into the virtual space you need to have a special helmet or goggles.

Thus, the use of immersive learning technologies today can become an effective tool in learning and revolutionize the training of the future professionals (Deep South magazine, 2020).

The use of immersive learning technologies in higher education involves taking into account a number of key points on which the principle of visualization in education is implemented. Thus, this principle does not deny, but on the contrary expands and complements the acquired knowledge, taking into account current trends in the development of modern information and communication educational technologies and scientific-technological progress. Immersive technologies in education enhance the importance of visualization in the process of learning due to deep immersion in the virtual environment, the role of which is very important – enriching students with complex sensory cognitive experience necessary to master abstract concepts. The human sensory system as the first degree of cognition must be strengthened through deeper immersion, the impact on the senses, which contributes to the acquisition of knowledge in the form of concepts, rules, laws, which are laid down at the next stage. Providing knowledge with objectively existing reality should continuously accompany the learning process based on feelings. To increase the effectiveness of learning, the principle of immersion requires, above all, the use of immersion tools, based on visual modality. The principle of complexity in the immersive approach involves the impact on all human senses to the perception of educational material.

The effectiveness of the principle of visualization in the use of immersive technologies is confirmed by the fact that of the five organs of human perception today it is possible to use three – sight, hearing, touch.

Let us consider the experience of using immersive learning technologies in the world's leading universities. Interesting for our research is a survey conducted by the company Sony in July 2019 on the use of video in higher education institutions (Ruddock, 2019). In total, the survey was conducted in 13 European countries, in which 123 educators took part. The study showed that the demand for virtual reality is growing today, and several respondents stressed on the benefits of using VR in education: with AR/VR, the potential is further enhanced by the ability to create more interactive and autonomous learning systems. VR allows

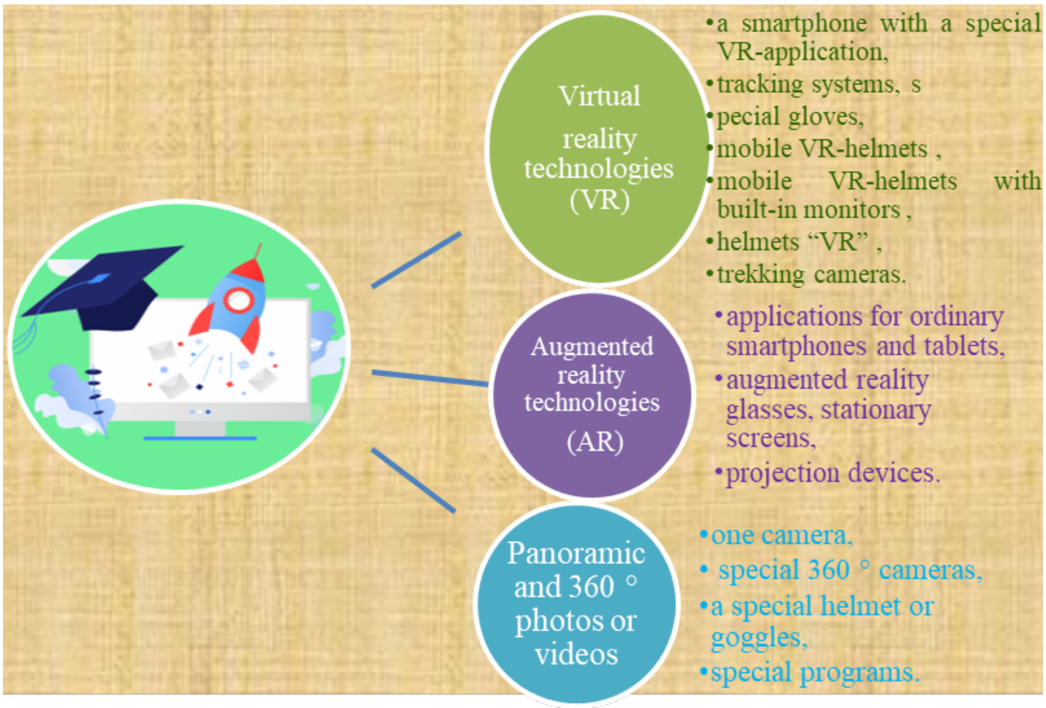

Figure 2: Components of immersive learning technologies.

teachers to create interesting life and interesting learning experiences when students can interact with 3D objects and environments. Students can take virtual tours of artists' exhibitions, explore space or explore the internal organs of a human (Ruddock, 2019).

Today, VR is actively used in the health care training system to provide medical students with an overview of surgical procedures with their own eyes without being in the operating room. Teachers can simulate the situation and ask students to perform exercises that they could not safely perform in reality, or interact with artifacts that would not otherwise be available.

The researches have shown that in a socio-constructivist approach to learning, the most effective educational activity is the experience gained, which involves the acquisition of authentic knowledge in the context of a personally realistic situation. Therefore, the use of immersive technologies is particularly suitable for providing practical experience. Modeling allows students not only to reproduce and practice routine situations, but also to have access to experiences that would be unattainable – due to difficulties, costs, dangers or simply the impossibility of obtaining it in the real educational process. However, their effectiveness depends on the ability to create an environment where the learner feels truly immersed in the environment and the story, going through the real experience.

The positive side of using immersive learning technologies in the process of training the future professionals at the university is to make the learning process exciting and more efficient.

The use of immersive learning technologies provides a deep understanding of the material by the student with the possibility of its further application in real life (teach.its.uiowa.edu, 2016).

Immersive learning technologies should be used to attract the intellectual abilities of students to a more effective learning process. They provide a safe and realistic environment for involving students in learning and practice, where they learn these methods and use them effectively in the training of the future professionals in various fields. For example, in the training of the future archaeologists to perform work on archaeological excavations; in the training of the future pilots, to guide the landing of aircraft on the aircraft carrier or in the training of the future doctors for surgery. The advantage of using these methods is that the computer system can track the progress of student learning and report any errors (teach.its.uiowa.edu, 2016).

Researchers at the University of Maryland have found that people remember information better when it is presented in VR than a two-dimensional personal computer. It means that VR education is more effective than learning with the use of tablets or computers. Researchers at the university conducted a study in which they asked two groups of people to remember the location of certain images. During the experiment, one of the groups used virtual reality helmets, the other – ordinary computers. The group that studied the image with VR helmets showed a result 10 % higher than the participants of the other group (Biggs, 2018).

Universities and colleges have always been at the forefront of introducing new technologies, driving progress and training the next generation of scientists, developers and entrepreneurs (www.classvr.com, 2020). Therefore, let's consider the experience of using immersive learning technologies on specific examples.

During the global pandemic, immersive learning technologies are actively used in distance learning in the world's leading universities, which allows, in particular during video conferencing to improve the effectiveness of learning. For example, professors at the University of British Columbia are already lecturing using immersive teaching methods (www.classvr.com, 2020).

For example, at the Central Pacific Institute in Hawaii, students who spent a few minutes using immersive technology for social education regarding the prospects of a homeless person noticed how they realized how easily they could find themselves in the same situation. "Becoming Homeless" is a project developed by Stanford University's Virtual Human Interaction Laboratory (VHIL) to determine the level of empathy for the problem of homelessness, but despite the feelings of discomfort and inconvenience received by students' own practical experience. Students and teachers usually report the consequences of the project implementation as "positive" (Bonasio, 2019, p. 7).

Another VHIL project that demonstrated the effects of ocean oxidation on coral reefs was conducted at Punahou International University.

So after the application of immersive technologies, in particular, using elements of the game, students gained some interactive experience. They ran their hands through bubbles coming out of coral reefs, causing students to have negative emotions about the environmental problem. The students noted that they are very disappointed that human activities can harm a beautiful and pristine ecosystem (Bonasio, 2019, p. 7).

Thus, analysing the world experience of implementing immersive technologies in the educational space of universities, we can identify the positive aspects of their use:

- *Visualization*. In the virtual space, a person can view any process or object in detail without obstacles. For example, for medical students through the application Anatomyuo (anatomyou.com, 2021) (3D application that teaches human anatomy for minimally invasive procedures, a person can study the structure of the body in the smallest detail), and for students of natural sciences it is advisable to offer the application Operation Apex (store.steampowered.com, 2017) which can demonstrate with the help of the adventure game all the riches of the underwater world. It is worth noting that the demand for exciting and interactive experiences continues to grow not only in the sphere of education but also in other areas.

- *Concentration and effectiveness*. Concentration is focusing on educational material. In the virtual environment, students are not distracted by external irritants.

- *Effectiveness*. Students who have used virtual reality technologies to study the learning material show better learning outcomes. Thus, Wu et al. (Wu et al., 2020) during an experimental study confirmed the effectiveness of the use of virtual technologies to improve student learning outcomes. Scientists conclude that immersive learning technologies can improve both students' knowledge and develop practical skills by supporting the effect of "real-time learning" (Wu et al., 2020).

- *Maximum involvement*. Immersive technologies provide the ability to fully control and change the scenario of events. Students at history faculties can witness historical events, students at physics and chemistry faculties can conduct their own physics or chemistry experiments, and math students can solve a problem in a playful and understandable form. Art students can attend a virtual tour, exhibition or concert.

  However, it should be noted that research and teaching staff are increasingly choosing the means of immersive learning technologies due to the potential pedagogical benefits. Immersive technologies, when used correctly and strategically, can provide a basis for increasing student engagement, immersion, interaction, enjoyment, and thorough deeper learning process. However, due to the development of understanding of the potential of immersive technologies teachers should begin to develop the quality content of education, rather than using technology as a fashion trend or end in itself (www.monash.edu, 2021).

- *Security*. With the help of immersive technologies a person can work as a lifeguard in a fire, for architects, engineers for computer simulation of any complex project, to conduct a complex operation, control military equipment, space shuttle, to conduct an experiment with hazardous chemicals without harming oneself or environment.

- *Reducing the financial costs* of training tools in training specialists, because software or virtual training tools are cheaper than real machines and equipment used in training the future professionals (using a smartphone or tablet a person can get a virtual endoscope, tomograph, model airplane, tank etc. (Kovalchuk et al., 2020; osvitoria.media, 2019).

Immersive technologies play the important role in educating students with special educational needs. After all, with the help of immersive technologies, one can create an inclusive learning environment, taking into account the needs and capabilities of each. This can be one of the important steps in democratizing knowledge.

By studying the experience of using immersive technologies in the world's leading universities, we can determine how they can affect the results of training of the future professionals – for example, reduced cognitive knowledge, brain load, allowing to gain real experience through the visualization of complex ideas and structures. This not only dramatically increases the involvement of students, but also allows students to absorb complex information more effectively and retain it longer. Perhaps most importantly is the fact that this is achieved in the holistic context that significantly increases the transfer rate (i.e. the ability to successfully adapt and apply what is learned in different real-life scenarios) (Bonasio, 2019, p. 2).

At the same time, with all the positive aspects of their use in the educational space of higher education institutions, their capabilities should not be overestimated. After all, immersive learning technologies cannot completely replace a highly qualified teacher in the educational institution. For example, a team of scientists studying the problem of implementing immersive and interactive educational technologies (Education 5.0 and Industry 4.0) in Malaysian universities identified the following disadvantages of their use: insufficient logistical infrastructure and high financial costs for the development of the content (Kamal et al., 2019).

Today, scientists often note a negative trend, when the use of information technology has priority over the traditional educational process, i.e. educational decisions are implemented without proper consideration and study of the pedagogical context in which they will be applied. This can be seen in education in particular, where success is invariably associated with the effective interaction of the student with the teacher and building feedback with the student, which gives priority to the learning outcome.

4 DISCUSSION

We studied the problems of implementation of immersive technologies in higher education institutions of Ukraine. In order to determine the level of awareness of students and research-teaching staff of Ukrainian educational institutions with the use of immersive learning technologies, we conducted anonymous survey at Lviv Ivan Franko National University, Volodymyr Hnatiuk Ternopil National Pedagogical University, Khmelnytskyi Humanitarian-Pedagogical Academy. Teachers and students (a total of 112 people) were asked a number of questions. The list of questions and answers are given in table 1.

Let us analyze the answers of respondents. To the question: "Do you use virtual or augmented reality technologies in your classes?" 75 respondents said they had never used it, 37 respondents said they had used augmented reality technology and only 2 said they had "written augmented reality software".

To the question "Do you know that today a person can plunge into virtual reality even with a regular smartphone?" 102 people said yes, but there was also the answer: "And yesterday a person could plunge into virtual reality with the help of an ordinary book".

To the question "Do you know which virtual or augmented reality technologies are supported in other higher education institutions?" only 30 respondents answered yes and only 1 respondent stated that such technologies are used in Tech StartUp School of Lviv Polytechnic.

During the survey, 64 respondents (all students) answered that they like to use a smartphone, tablet, augmented reality glasses for games. However, only 56 respondents answered that they visited museum exhibitions, art galleries, and virtual reality concerts, as there were no other options in 2020.

It is interesting that 108 respondents who took part in the survey said that they actively use computers, tablets, smartphones and other gadgets, which improve the quality of education, while 6 people stated that they do not use any technical teaching aids during their classes.

Based on the analysis of the answers to the question "Are you familiar with the term "immersive technology"? What do you think it is?" we concluded that the essence of this word is clear to 100 % of teachers, but a small percentage of students. However, in individual conversations we found that teachers and students are interested in learning more about the features of the use of immersive technologies and there

Table 1: The results of a survey of teachers and students.

Question	The number of positive responses / % of the total quantity	The number of negative responses / % of the total quantity	Note
1. Are you familiar with the term "immersive technology"? What do you think it is?	35 / 48.2 %	54 / 47.4 %	5 / 4.4 % answered inaccurately, incompletely
2. Do you use virtual or augmented reality technologies in your classes?	37 / 32.4 %	75 / 65.8 %	2 / 1.8 % respondents answered that they wrote software for AR
3. Do you know which virtual or augmented reality technologies are supported in other higher education institutions?	30 / 26.3 %	84 / 73.3 %	
4. How do you use computers, tablets, smartphones and other gadgets in your classes?	108 / 94.7 %	6 / 5.3 %	All interviewed teachers answered that they actively use gadgets for distance learning
5. In your opinion, is it possible to safely gain practical experience with the help of virtual and augmented reality technologies?	92 / 80.7 %	18 / 15.8 %	4 / 3.5 % of the respondents found it difficult to answer, 2 answered "maybe"
6. Do you know that today a person can plunge into virtual reality even with a regular smartphone?	102 / 89.5 %	12 / 10.5 %	
7. Have you visited museum exhibitions, an art gallery, a concert in virtual reality?	56 / 49.1 %	58 / 50.9 %	
8. Have you used a smartphone, tablet, augmented reality glasses for games?	64 / 56.1 %	50 / 43.9 %	

is a need for a deeper critical analysis of the use of immersive technologies in the educational process of higher education on the example of other universities.

Thus, having analyzed the answers, in particular a large number of negative answers to the first, second, third and sixth questions, we consider a promising area of improving the educational process of Ukrainian universities, studying world experience of using immersive learning technologies for their implementation in the future, creating opportunities for digital learning.

During the research in order to determine the level of awareness of students and research-teaching staff of national educational institutions on the use of immersive learning technologies, we conducted the anonymous survey at Lviv Ivan Franko National University, Volodymyr Hnatiuk Ternopil National Pedagogical University, Khmelnytskyi Humanitarian-Pedagogical Academy. After analyzing the answers of research-teaching staff and students, we came to the conclusion that today a promising area for improving the educational process in Ukrainian universities is to study world experience in the use of immersive learning technologies for their implementation in the future.

5 CONCLUSIONS AND PROSPECTS OF FURTHER RESEARCH

In the process of studying the problem of the use of immersive technologies in the educational space of universities, we have generalized that such technologies are used in the training of the future archaeologists to perform work on archaeological excavations; for architects, engineers for computer modeling of any of the most complex projects, in the training of the future pilots to guide the landing of aircraft on the aircraft carrier; to prepare rescuers to put out fires and rescue people; in the training of the future physicians for surgery or for experiments with hazardous chemicals. Immersive technologies play the important role in educating students with special educational needs to create inclusive learning environment taking into account the needs and capabilities of each.

Having analyzed the world experience of using immersive technologies in universities around the world, we found that these technologies are used in quite unexpected ways:

- immersive learning technologies are actively used during distance learning, which allows, in particular during video conferencing to improve learning efficiency (University of British Columbia);
- to determine the level of empathy for the problem of homelessness, which allows to obtain the social experience of a person who becomes homeless (Central Pacific Institute in Hawaii);
- to study the effects of ocean oxidation on coral reefs, to provide knowledge about the environmental problem, so that the students understand the damage to nature caused by human activities (Punahou International University).

Thus, the use of immersive technologies in the educational space of universities is applied not only in the process of training specialists for various sectors of the economy to obtain professional competencies, but also to gain social, emotional experience and to update environmental issues.

Our research does not outline all aspects of the problem of using immersive learning technologies in the educational space of the world's leading universities. These and other problems today are the most promising area of scientific pedagogical thought, and can project the further introduction of immersive technologies in the educational space of national higher education institutions, taking into account the positive experience of universities.

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Opportunities and Ways of using Laboratory Equipment in a Distance Learning Environment

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Keywords: E-Learning, Remote Labs, Virtual Laboratory Work, CNC, 3D Printing.

Abstract: The paper considers the issue of possibility and ways of performing laboratory works in the conditions of distance learning as well the experience of using virtual works as a forced replacement of traditional practical training. The peculiarities of distance learning organization under conditions of coronavirus pandemic are analyzed. The problems faced by the higher educational institutions in this situation based on the analytical data of the international commissions are reviewed. The problems that arose in the use of laboratory equipment for work in the conditions of the pandemic are analyzed. The advantages and disadvantages of remote execution of laboratory works are discussed. The problems arising when replacing real laboratory work with virtual ones are considered. The example of performing laboratory works under distant learning conditions by providing remote access to them via the Internet on the example of bioelectronics and biomechanics laboratory is considered. The directions of further development of virtual practical work at the department of computer information technologies are formulated.

1 INTRODUCTION

Higher education institutions have faced transformation before with the porting of many educational materials and activities to online platforms such as Moodle or Blackboard (Mintii, 2020). Recent measures in response to the COVID-19 pandemic have brought about an unprecedented transformation in higher education (Bakhmat et al., 2021; Trubavina et al., 2021). Almost all classrooms have moved from traditional classrooms to virtual classrooms supported by video conferencing platforms such as Zoom, Webex, Microsoft Teams, and others.

After the outbreak of the coronavirus pandemic, the Department of CIT DSEA, like most others, was forced to switch to distance learning using appropriate modern platforms. However, outside of distance learning, there is often an important part of the educational process – laboratory work using special equipment. This issue is especially acute for technical specialties. It is impossible to imagine the process of teaching technical specialties without its laboratory component – this is due to the formation of the professional competence of specialists with a high level of training.

Therefore, the problem of organizing laboratory work in the context of distance learning is very important.

The *purpose* of this paper is to investigate the possibilities and ways to conduct laboratory work in a distance learning environment.

2 RELATED WORKS

Consideration of the specifics of conducting a laboratory workshop in a distance learning environment should begin with a consideration of the specifics of education in the context of the coronavirus pandemic in general. The pandemic, on a global scale, has affected not only all spheres of public life (Semerikov et al., 2020), but also each person individually, and not only on the physical but also on the psycho-emotional levels (Velykodna, 2021). This was

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especially acutely felt by the education sector since it required a total transfer of all educational activities to a distance mode. According to Executive Director of Chandigarh University (India) S. K. Tripath, “The new coronavirus has affected employment, education, energy, agriculture and other areas of the global economy, including the emotional state of citizens. Higher education institutions (HEIs), including universities, colleges and other institutions of higher education, are no exception” (UN, 2020). According to UNESCO, the COVID-19 pandemic has led to the largest disruption in education systems in history, affecting nearly 1.6 billion students in more than 190 countries and on all continents. School and other educational closures have affected 94% of the global student population, with 99% in low- and lower-middle-income countries (International Commission on the Futures of Education, 2020). According to the same UNESCO, 826 million students in the world do not have personal computers, 706 million (43%) do not have access to the Internet (Faek and El-Galil, 2020).

In high school, the use of web-based distance education is expanding rapidly. This requires constant improvement of the technological and methodological support of the educational process. Failure in education is a serious threat to the entire society. Therefore, educational institutions must respond quickly and ensure the continuity of educational processes. Research is underway to develop technical, organizational, and pedagogical changes that educational institutions must implement to use different methods of interaction, ensure continuity and provide high-quality education (Bojović et al., 2020).

Research on the advantages and disadvantages of distance education is important (www.eztalks.com, 2017). Many universities are researching to examine the effectiveness of distance learning at universities in light of the coronavirus pandemic and to identify the barriers that university students face. Bataineh et al. (Bataineh et al., 2021) is pointed out that distance learning requires an exceptional environment, ability, and IT skills in addition to smart devices and applications that enable video conferencing. Another important area is the study of methods and means for involving students in the online learning process (Chen et al., 2021). An important step in the transition to online of many laboratories that are used in higher education, especially in STEM fields. This is important for students of those specialties that require access to physical objects: devices, sensors, control devices. One of the ways to solve this problem is to use Remote Lab and Virtual Lab technologies when programming an embedded system and applying them to managing technical objects (Zubía and Alves, 2011; Sancristobal et al., 2012). A virtual laboratory is a software and hardware complex that allows research without direct contact with real production or educational equipment, or in the absence of it (Sancristobal et al., 2012). The Remote Lab includes real technological equipment, software, and hardware for controlling the technological complex and analog-digital conversion of measuring signals from sensors installed on the equipment. At the same time, it should be ensured: the operation of the equipment, a reliable access channel via the Internet, access dispatching and accounting of work performed, video stream transmission using appropriate equipment, etc. These tasks are solved, for example, in the GOLDi system (GOLDi, 2021). Within the GOLDi Remote Lab, interactive content objects can be offered to students to digitally support learning processes. These are digital, immersive tools that allow you to explore learned content with predefined or self-created examples. Virtual Lab emulates laboratory equipment through the use of mathematical models (Vasilyeva and Portnyagin, 2017; Tarasov et al., 2020b). It is also necessary to improve the technologies of the educational process based on the use of IT.

To ensure a proper response to emerging problems, universities need to focus on changing not only teaching methods but also the very approaches to teaching, organizing the educational process, and to do this quality and quickly. On the other hand, it became necessary to abandon the traditional method of planning and implementing educational programs. A regulatory component of the educational process during a pandemic in the Donbass State Engineering Academy was the “Regulations on distance learning for applicants for higher education at the Donbass State Engineering Academy in special conditions” (DSMA, 2020). The implementation of this provision is based on the expansion of distance learning opportunities through the digitalization of education, which, on the one hand, requires an analysis of the digital infrastructure of the academy, and on the other, its management. This analysis led to the solution of a global problem for technical universities – how to implement a laboratory practice on special equipment in this mode.

All laboratory work can be classified according to the type of disciplines where they are used. This applies more to special disciplines, where the student is often given the task of measuring the characteristics of any process using real devices or maintaining the process occurring in a given state. It is also possible to set some target state, which should be achieved in the process of laboratory experiment by appropriate actions of the student (Tarasov et al., 2020a).

3 CASE STUDY

Consider the possibilities and ways of remote use of laboratory equipment of laboratories of bioelectronics and biomechanics of the Department of Computer Information Technologies of Donbass State Engineering Academy. They are equipped with modern research and production equipment that was purchased as part of the work in the international project BioArt Erasmus+ and allows research on the use of modern computer information technology in electronics, mechanics, biomechanics, and mechatronics. The production equipment of the laboratories includes machines with computer numerical control (CNC) and a 3D printer. This equipment allows to significantly expand the experience of students in the field of computer modeling and automated design in such CAD-systems as AutoCAD (2D modeling) SolidWorks and PTC Creo (3D modeling) by moving from computer models of objects to their material embodiment.

Computer numerical control means a computerized control system that reads the instructions of a specialized programming language and controls the drives of metal, wood, and plastic machining machines and machine tools. The CNC system interpreter translates the program from the input language to the control commands of the main drive, feed drives, controllers of the machine units (enable / disable cooling, for example). To determine the required trajectory of the working body as a whole (tool/work piece) by the control program (CP) uses an interpolator that calculates the position of the intermediate points of the trajectory specified in the program end. CNC machining increases productivity and accuracy of operations, guarantees a constant level of quality, which in most cases far exceeds the quality of traditional manual machining. Many orders that previously had to be abandoned can now be fulfilled easily and effortlessly, which in the meantime is considered exclusive and is the category of the largest profit (Mikhieienko, 2020b).

CNC machines are represented by the following models. CNC machine Krechet-4060 manufactured by the Ukrainian company "CNC machines" (figure 1). This machine can be used for 2D and 3D milling of all types of plastics, wood, plywood, MDF, foam, composite, and light metals. The working field of the machine 400 x 600 mm, stroke on the Z-axis 100 mm, processing error 0.08 mm.

These are the Sherline 5410 CNC drilling and milling machine and the Sherline 4410 CNC lathe (figure 2). Sherline is located in the United States and is widely known in the world for quality small machines. These machines allow you to perform machining of parts in both software and manual control mode. The free version of Mach 3 is used as software for controlling motor controllers. It is enough to control the processing of medium-sized parts.

The Sherline 5410 CNC drilling and milling machine have a motor power of 0.6 kW, a spindle speed range of 70–2800 rpm, axial movement: X/Y/Z – 220/127/159 mm, respectively. Stepper motors to control the movement of the axes with a capacity of 0.2 kW.

The Sherline 4410 CNC lathe has a motor power of 0.6 kW, spindle speed range 70–2800 rpm, spindle bore diameter 10 mm, rear headstock quill stroke 45 mm, rear headstock quill cone – MK1, turning diameter over frame 180 mm, turning diameter above the transverse caliper 90 mm, the distance between the centers 430 mm, the course of the transverse caliper 110 mm. Stepper motors to control the movement of the axes with a capacity of 0.2 kW. There is a complete set of equipment that allows you to process not completely cylindrical parts and cut threads. The machine allows to carry out processing with simultaneous movement of the tool on two coordinates.

Additive technologies have made a big qualitative leap in recent years, moving from the category of industrial equipment to personal devices. Due to this, there is an opportunity for the widespread introduction of this technology in the educational process. This allows not only to refine and expand the classic laboratory workshop but also to increase students' motivation and develop their competencies in the field of new technologies and their practical application.

In the conditions of active modernization of education, equipping universities with modern computer technology and transition to various forms of e-learning, there is an active introduction into the educational process of various virtual simulators and complexes designed to replace real physical experiment, the base of which is often not updated and obsolete over time. But a real physical experiment plays a very important role in the learning process. It allows not only to instill skills in working with equipment, but also to develop research and cognitive interest in students (Mikhieienko, 2020a).

The presence of a large number of 3D printing technologies on the one hand gives a wide field for choice, on the other hand, imposes certain restrictions on their implementation. One of the most common 3D printing technologies is FDM (fused deposition modeling).

Among the main advantages of this type of printing are the following:

- the use of fairly compact printing devices that do not require special knowledge and skills in instal-

Figure 1: CNC machine Krechet-4060.

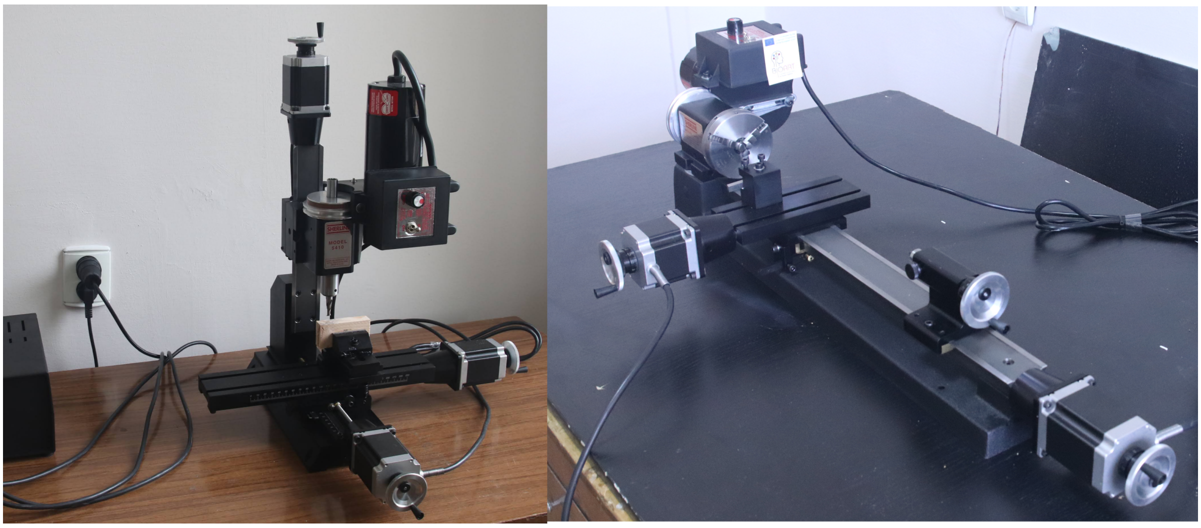

Figure 2: CNC machines: Sherline 5410 CNC and Sherline 4410 CNC.

lation and operation;

- relatively low (compared to devices that use other technological processes) cost, both the devices themselves and consumables;
- the principle of the press is simple and technological that does not demand special places of installation;
- openness of technology, i.e. the possibility of its improvement and modification (the possibility of assembling a printing device from a ready-made designer or set of components).

Equipment for additive production in laboratories is represented by a 3D printer FARM2 (figure 3). This 3D printer has a printing area of 200x200x200 mm, implements ULTIMAKER kinematics, and has the ability to print the following types of plastic: PLA, ABS, PVA, Nylon, HDPE, PCL, PET-G.

Let's move directly to consider the possibility of remote laboratory work on CNC machines and 3D printers. Unfortunately, at the moment, for the full operation of machines and printers, some operations can only be performed by humans. For CNC machines it is the installation and replacement of working tools, blanks and finished products, chip cleaning. For 3D printers, this is a replacement for plastic and printed models. Although for some of these operations there is already a solution for full or partial automation (tool replacement and chip removal), laboratory work on CNC machines and 3D printers without the intervention of a teacher or laboratory assistant is currently impossible. But, despite this, it is already possible to remotely monitor the operation of CNC machines and 3D printers, get the parameters of their work and quickly adjust them. Consider ready-made solutions in this area.

In (Rocha and Tostes, 2018) the possibility of quality control and remote control of the device using

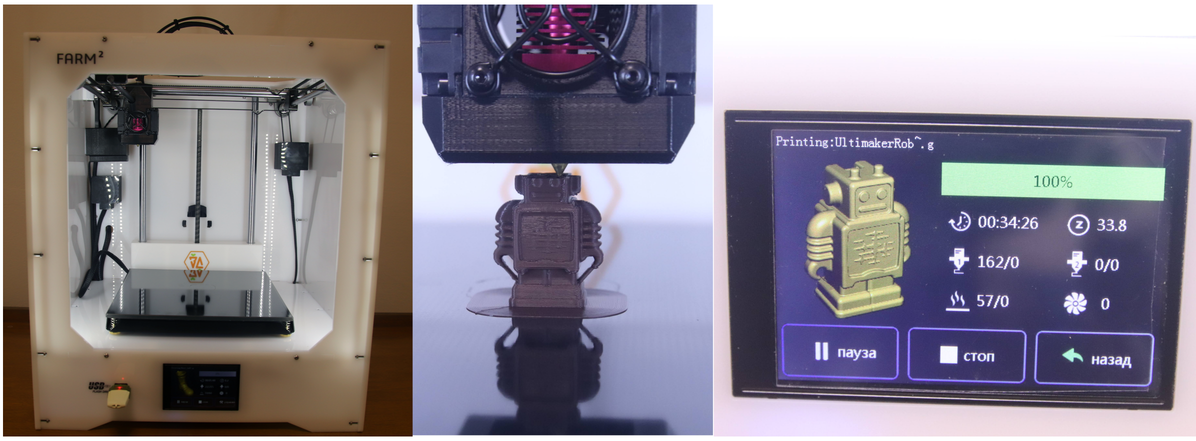

Figure 3: 3D printer FARM2.

a server is considered. The development of a server for CNC machine tool management is considered in order to improve the user experience and expand the capabilities of the device, including remote monitoring of the device. The work is based on the implementation of synchronous engine control using such parameters as: Constant snap period, Constant jerk period, Constant acceleration period, Constant velocity period, and imposed snap bound. This set of parameters is a classic for CNC machines. To control the device, it uses a simple built-in system (single-board computer) Beaglebone Black with control through the OS Linux kernel, acting as an operating system. Due to the choice of OS Linux as the operating system, the firmware software is open source.

To implement the firmware used a patch RTLinux (Savant and Desai, 2007), designed to work with components in real-time. The exchange of information between blocks in real-time is through shared memory. A program in C++ using a server on Linux was developed for remote device management. The program works as a server processing client requests. To implement the client part in the course of work were considered 3 options: a console application on Linux, a console application on Windows, and an application with a graphical interface. PRUSS firmware was developed to perform real-time calculations. The server application used writes data to the shared memory, which uses the PRUSS firmware to generate control signals and exchange their states via GPIO. The board and computer interact via a TCP connection via an Ethernet port.

One of the most common open-source firmware for remote control of 3D printers is the RepRap system. In (Liu et al., 2017) its application is considered. The web server is developed in Python in conjunction with the Tornado framework. The authors highlight some advantages of using the above framework to implement the server. The main advantage is the lightness of the system and the ability to scale to service up to tens of thousands of open connections, which is well suited for the operation of the printer management system during long-term use of the connection. The paper describes in detail the principle of client-server communication based on the HTTP protocol, which allows studying in detail the process of information transfer. The client part is a web page. As a result of firmware research, promising directions of technology development are proposed, including improving the functionality of the remote Rep-Rap server.

To improve the user experience when working with printing devices, the capabilities of 3D printers need to ensure their extensibility. One of these modifications is to provide full or partial tracking of the behavior of device modules. Monitoring the printing process requires access to readings from various types of sensors and printer components. Monitoring the printing process requires access to readings from various types of sensors and printer components. This system allows you to automate the collection of information about the device for subsequent display of data to the user to analyze the operation of the printer. There are also more advanced technologies for tracking the printing process, in which the status of the printer is monitored by analyzing readings from sensors and the position of the head using a neural network (Zhang et al., 2019). The article analyzes the operation of the position sensor, which is used to collect data on the status of the printer. It uses the prediction root mean square error as an indicator to describe the operating state of the printer. As a prospect for the development of technology, the introduction of such analysis into the remote control system of a 3D printer should be considered, it will allow monitoring the quality of the printing process and remotely

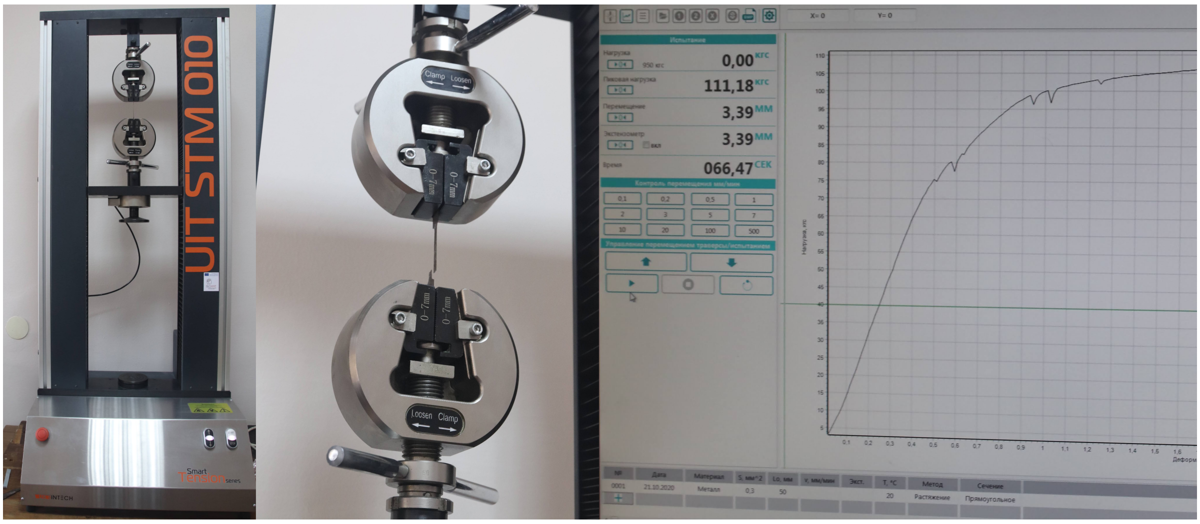

Figure 4: Universal testing machine UIT STM 001.

monitoring the health of the device.

Also, many amateur projects for remote control of 3D printers on the use of open-source software (more often OctoPrint) and single-board computers Raspberry Pi and Orange Pi are posted in the public domain.

Consider the ways of remote use of equipment for research and development. The study of the mechanical properties of medical purposes, for example, metals, composites, threads, are investigated on a universal testing machine UIT STM 001, which can be completed with a variety of equipment and devices, and the software allows testing according to various standards (GOST, GB, ASTM, DIN, ISO, etc.) and techniques (figure 4). Using an application programming interface (API) allows you to develop software products to extend the capabilities of the testing machine.

Full automation of the testing machine has the same obstacles as the automation of machine tools and 3D printers - human intervention is required, in the case of a testing machine, to replace prototypes. The ways of partial remote translation of laboratory work on a testing machine are also similar – remote monitoring and control.

But in the case of a testing machine, an alternative way is possible – replacing real laboratory works with virtual ones. In (Vasilyeva and Portnyagin, 2017), a prototype of virtual laboratory work was developed for use in the educational process in the course ”resistance of materials”. The software package in real-time provides a full cycle of laboratory work: preparatory stage (training), installation and removal of the sample, performing measurements of the sample before and after testing, test, plotting a tensile diagram to determine the main mechanical strength characteristics (figure 5). The tests have shown that the use of modern technologies for performing virtual laboratory work in the educational process significantly increases the quality and efficiency of the learning process and can be used in conjunction with work on real equipment.

Experience has shown that most students had no problems with running the labs and completing them. We believe that the best result is achieved when they are conducted in real-time, with the teacher’s explanations via video link and dialogue with the students.

4 CONCLUSION

Developed courses are at the stage of implementation in the educational process. The study of the features of laboratory work in the conditions of distance learning showed:

- at this point, it is impossible to make complete automation of equipment for remote laboratory work. Human intervention is required for some operations. This makes it relevant to develop communications between students, teachers, and laboratory assistants using modern electronic means of communication, planning, and optimization of the working time of laboratory equipment;
- there are many ready-made solutions for remote monitoring and control of laboratory equipment using open source software, single-board computers, cloud services, server, and client applications;
- in some cases, an alternative to laboratory work

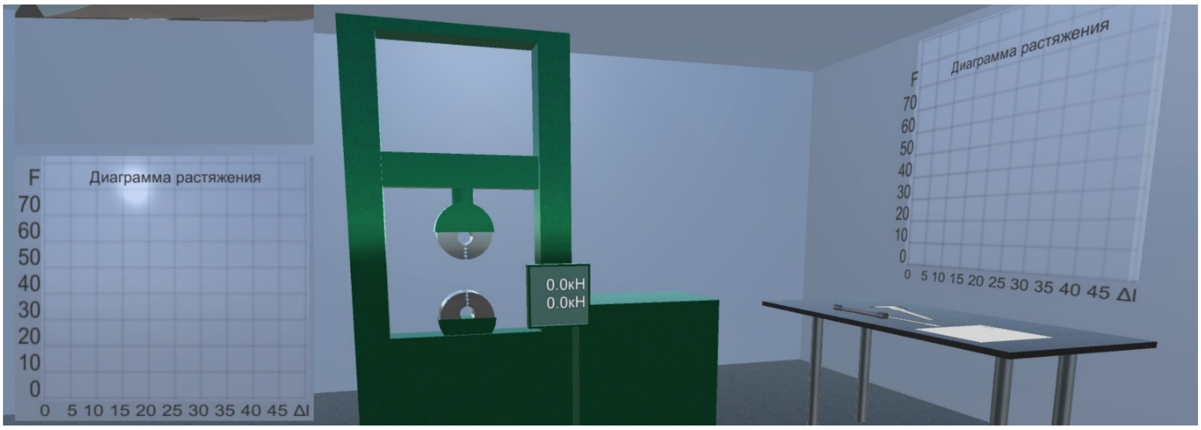

Figure 5: Program interface with three-dimensional models, interface, and mini cameras for simultaneous control of all processes (Vasilyeva and Portnyagin, 2017).

on real equipment is to replace them with virtual laboratory works.

The authors do not view the virtual labs as a complete substitute for the real ones. However, we think that they will organically complement classroom work after the pandemic is over.

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Augmented Reality in the Literary Education of Primary School Children: Specifics, Creation, Application

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Keywords: Augmented Reality Technology, 3D Visualisation, Creative Thinking, Emotional Intelligence, Interactive Travel Game.

Abstract: The authors worked on expanding the methodological basis for the use of augmented reality on the examples of alphabets in accordance with the objectives of the school program of the 1st-grade of the New Ukrainian School, namely the content lines: "Interact orally", "Exploring the media", "Exploring linguistic phenomena". The methodological aspect of the application of augmented reality on the basis of interactive art books has also been expanded. In particular, within the line "Theatricalize" it is proposed to involve students in stage art, in the conditions of which they gained experience of performance, tried to improvise. Observation of artistic expression through augmented reality, work with interactive coloring pages and stickers, expression of appropriate emotions through acting ensures the development of the child's emotional intelligence, creative thinking, initiative, self-awareness, self-control, ability to overcome barriers associated with uncertainty and risks, effectively cooperate with and understand one another. The result of the research characterizes different directions of application of augmented reality in the literary field of primary education: visualization, observation and research of artistic image, demonstration of its expression; visualization, observation and research of the artistic world of a literary work; organization of the reader's interaction with the literary hero; organization of game activities in the lesson of literary reading (study of the work with the help of a game developed by means of augmented reality); organization of theatrical performances with the help of interactive bracelets and stickers with AR applications. This study is devoted to the creation of an augmented reality appendix to the topic "Ukrainian folk tales". Due to the fact that the leading activity in primary school is gaming, the AR application based on a fairy tale as a game-trip was created. The development of the application provides for the implementation of further tasks: analysis of the work, interpretation of the work, activation of the emotional impact of works on the reader. The augmented reality for the accompaniment of the creative reading of the fairy tale was created with the help of Unity programs and the Vuforia plugin. The basis of the game-trip is a fairy-tale map with stations and special interactive tags. A specially designed program attaches a virtual AR object to the label and activates the image of the hero, the episode of the fairy tale, the text of the question on the screen.

1 INTRODUCTION

1.1 The Problem Statement

New virtual (VR) and augmented reality (AR) technologies have quickly gained popularity around the world. Currently, visualized content on various topics is used with the help of modern electronic devices in various fields, such as: science, production processes, technology, marketing, design, entertainment,

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medicine, education, etc. VR and AR applications are already actively used as teaching aids in schools in America and Europe. Augmented reality technology has become especially popular due to its easy and convenient use. The availability of smartphone or tablet, which can be used for individual tasks, observations, research, as well as for group projects, is enough to work with AR. With the help of AR applications with smartphones in hands, foreign and domestic primary school students have the opportunity to explore the solar system, water molecules, flora and fauna, travel, enliven the pages of the alphabet, visualize artistic images and the world of literature, etc. By extrapolating the world experience of activating augmented reality in school practice, scientists-methodologists and teachers-practitioners in Ukraine develop their own AR applications and substantiate methodological models of their implementation in education.

Modern development of information and communication technologies allows to modernize the educational process in primary school as much as possible in accordance with the challenges of the time and the requirements of the reformed education. The linguistic and literary branch of primary education was no exception. In particular, the “Living Alphabet” has appeared on the desks of first-graders in Ukrainian schools, the visualization of which is provided by the FastAR Kids application in smartphones or tablets (iOS, Android, iPhone). The interactive edition contains a game platform with special labels on the pages of the edition, which activate augmented reality in 3D format based on the plots of poems with amazing stories and animated characters. Some teachers use the alternative edition of the “Kobzar’s Alphabet” in the practice of teaching literacy to first-graders. This interactive book contains works by Taras Shevchenko for each letter of the alphabet, the illustrations of which come to life, move and talk with the help of the same FastAR Kids application. However, the methodology of teaching with the help of such books remains undeveloped, so the use of augmented reality in literacy lessons in the first-grade is not systematic, but rather situational.

The specificity of fiction, its imagery, organic integration into the multimedia space also suggest the need for partial revival of the artistic picture with the help of augmented reality technology in the reading process. While developing lifelong learning skills in primary school students, it is important to form an interest in books, to teach to feel the beauty that is embedded in the artistic word. The depth of perception of the work depends not only on the development of critical thinking and aesthetic sense, associated with a sense of beauty, understanding of the values accumulated in the artistic image, but also on emotional intelligence. Therefore, the development of dialogic interaction with works of art will be greatly facilitated by the use of augmented reality technology, which causes its visualization primarily emotional resonance and promotes the activation of the creative imagination.

1.2 Literature Review

We analyzed the current state of research on the use of AR applications in education (Chen et al., 2017); studied the experience of combination of AR with learning based on games in primary school (Makhachashvili et al., 2020; Pellas et al., 2019), the impact of integrating game approaches with augmented reality on learning (osvitoria.media, 2019; Sáez-López et al., 2019), improvement of learning efficiency and students’ motivation through the use of AR applications on smartphones (Chen, 2019).

Possibilities of application of AR technologies in different fields of education were considered by Pochtoviuk et al. (Pochtoviuk et al., 2020). The authors noted the great impact of presentation of educational material by augmented reality on the development of facial expressions, attention, stimulating thinking and increasing the level of understanding of information. Among the benefits, scientists point to realism, clarity, completeness, information and interactivity. The didactic potential of virtual information learning environment is determined by Bondarenko et al. (Bondarenko et al., 2020). Scientists emphasize such features of VR and AR as immersion, dynamism, sense of presence, continuity, causality, intensification of the process of cognition, saving time for processing the material. While acknowledging the effectiveness of learning with the help of VR and AR, the authors also point out the disadvantages, including low computerization, low number and low quality of software products (Bondarenko et al., 2020), difficulties in applying these technologies, such as: small experience in using this technology, lack of methodological literature, lack of developed methods of AR implementation (Iatsyshyn et al., 2020). Lacunae of augmented reality educational products are filled by practitioners who create mobile applications to visualize educational material, including the chemical structure of water and display video data from laboratory experiments to study subjects of the natural cycle in the primary school. Innovative is the experience of developing a mobile application LiCo.SolarSystem, designed to visualize the solar system using AR technology and study the alphabet using astronomical definitions (Midak et al., 2020a). According to the authors of the LiCo.STEM and LiCo.SolarSystem applications (can be downloaded from a publicly available Google Play Market resource), its contributes to the development of cognitive motivation of primary school students and educational energy, their imagination, creative initiative and research activity (Midak et al., 2020b).

Walsh et al. (Walsh et al., 2019) offer the development and implementation of educational tools using virtual and augmented reality for language learning in primary school. Sekerin et al. (Sekerin et al., 2017) outlined the prospects for the implementation of the latest educational technologies that allow to increase the effectiveness of teaching. Thus, in the course of the study, they found that 20% of students are ready to receive educational information from conventional sources, and 80% of students need inter-active perception of information based on augmented reality. Carrying out lessons with the help of virtual reality tools, according to scientists, contributes to the full involvement of students in the educational process and, accordingly, successes in the acquisition of knowledge (Sekerin et al., 2017). For primary school students in Ukraine, a textbook and universal didactic material from AR for the integrated course "I explore the world", aimed at developing research skills (Honcharova, 2019), has already been created.

The most of the publications on the identified problem testify to the possibility of using VR and AR technologies in the educational field for the purpose of visual modeling of educational material; supplementing its visualization; developing students' spatial ideas; research and experimentation skills; three-dimensional design, which saves time for learning information, accelerates learning and makes the process fun and engaging.

1.3 The Aim of the Research

Thus, augmented reality is increasingly used in primary education, special educational applications have been developed in the field of natural sciences, AR text-books have been created for primary school students for the course "I explore the world".

Among the many tools of augmented reality technologies in the educational process of primary school one use AR applications such as "Animals 4D" in the integrated course "I explore the world". Encyclopedias of the Ukrainian manufacturer with augmented reality iEXPLORE, which transfer the animal world from the pages of the book to reality, are designed to instill curiosity in children, to acquaint them with the magical world of animals, insects, beetles and dinosaurs.

The authors of this article outlined the prospects for the application of augmented reality in the linguistic and literary field of primary school. Several editions of works of art by Ukrainian and foreign writers with AR applications, which should be used in reading lessons, are named. We conducted a study of the effectiveness of the use of AR applications in reading lessons in primary school with the definition of their benefits for enhancing the reading activities of students (Nezhyva et al., 2020). However, there is a need for the systematic development of methods for applying augmented reality in literacy and reading lessons in 1st-4th grades and testing its effectiveness for the development of the subject and key competencies of primary school students.

The recommendations of the European Parliament and the Council "On the basic professional skills required for lifelong learning" refer to the formation of basic competencies that help individuals to socialize successfully. For the main competencies, among others, such reference frameworks as critical thinking, creativity, initiative, the ability to constructively manage emotions are named (ec.europa.eu, 2018). We believe that such personality qualities are formed during reading activities, which will be enhanced by augmented reality.

The study aims to develop a mobile AR application on the Android platform, designed to organize play activities of primary school students during reading lessons while studying fairy tales and modeling of methods of application of augmented reality technologies in the linguistic and literary field of primary education, which can be used by teachers and students for effective training on methods of literary reading in primary school.

2 DISCUSSION AND RESULTS

AR technologies provide a three-dimensional field of human perception of virtual information, which can be perceived as elements of real life. With the help of augmented reality, images, videos, text and graphics are projected beyond the screens of smartphones or tablets with the AR function. In this way, virtual objects are combined with the real environment. With the help of a 360° picture, the boundaries of the creative imagination of a junior school-child can be maximally expanded. Quality augmented and virtual reality content blurs the line between the artificial world and the real one. With the help of gadgets, as if through a window, the student observes an amazing image of the world (scientific, technical, artistic, etc.), explores, cognizes its laws, learns to change it for the better. Therefore, the use of these technologies causes maximum expression in students, and most importantly allows them to actively interact with various objects of study in three-dimensional space. Thus, augmented reality technologies allow students to perceive artistic images in an entertaining form of the game, to get closer to understanding the artistic world of a literary work. In this study we will take into account the most important advantages of immersive technologies, namely:

- clarity, which allows to easily examine in detail any process or object;
- concentration, which allows not to be distracted by external stimuli and focus on the lesson material;
- maximum involvement of students in the learning process;
- the effectiveness of awareness and memorization of important educational information, etc. (osvitoria.media, 2019).

Primary school students have the opportunity to begin their acquaintance with augmented reality in the 1st-grade. Today, many Ukrainian schools are provided with an interactive edition of "Living Alphabet" with the application FastAR Kids for smartphones and tablets (iOS, Android, iPhone). The pages of this alphabet can be revived from the first literacy lessons (figure 1). While working with this alphabet, we offer first-graders not only to listen to poems, fairy tales, useful information, but also advise teachers to set the following tasks for students: observe the heroes of stories, learn to interact with them, explore their appearance and emotional state, pay attention to the environment, orally describe what was seen and heard, etc.

Figure 1: Demonstration of augmented reality according to the publication "Living Alphabet".

A more complex, but not less interesting format of the interactive edition "Kobzar's Alphabet" (Kyiv, 2019) with the application FastAR Kids (figure 2). In special literacy lessons, this alphabet can be used as an alternative. Students are invited to get acquainted with the works of the classic of Ukrainian literature Taras Shevchenko in an interesting and relaxed way by means of "reviving" highquality illustrations to these works.

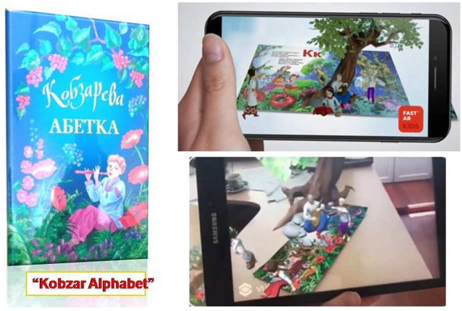

Figure 2: Demonstration of augmented reality according to the publication "Kobzar's Alphabet".

It is important that such an alphabet effectively helps first-graders with different levels of readiness to learn to read and understand words and sentences, provides an opportunity not only to update knowledge about the letters of the Ukrainian alphabet and corresponding sounds but also to hear the clear reading of Kobzar's poetic lines accompanied by augmented reality. The teacher is invited to draw students' attention to the melodiousness of the native language, to the beauty of Ukrainian landscapes, activated by the AR application, to emphasize the spiritual values of Kobzar's poetry. Thus, with the help of augmented reality, the tasks of the main semantic lines of study according to the current school pro-gram of the 1st-grade of the New Ukrainian School are realized, namely:

- *"Interact orally"*. Students perform actions to activate augmented reality following the listened instructions; answer questions on the content of what is heard and seen (who? what? where? when? how?); tell what is said in the text, activated by augmented reality; share their feelings and emotions from what they have heard and seen; tell what has interested them; reproduce emotionally in roles (with students or teachers) the dialogue of the characters; learn to use non-verbal means (gestures, facial expressions, etc.) according to the communication situation; repeat samples of coherent utterance (2–3 sentences) while preserving its content and intonation features; retell a short listened text based on augmented reality; independently build a short coherent statement based on the listened text or augmented reality.

- *"Exploring the media"*. Younger students, working with media products, learn to perceive the content and form of simple media products, among which there is not only the usual pictures, comics, cartoons, but also augmented reality, participate in its discussion; share their impressions of listened to / viewed media products.
- *"Exploring linguistic phenomena"*. Students explore speech sounds, their correct pronunciation by activating augmented reality applications, learn the correspondence of sounds and letters; observe the lexical meaning of words.

Thus, there is another effective means of teaching literacy to primary school children – augmented reality, which contributes not only to the successful study of the Ukrainian alphabet but also a casual acquaintance with classical examples of literature and spiritual values reflected in it, ensures the development of speech, imagination, critical thinking, emotional intelligence of primary school students.

In primary school, it is appropriate to conduct interactive reading lessons using art books for children with augmented reality, in particular a series of books "Read and Play" by the Ukrainian publishing house Art Nation Publishing. One has confirmed the effectiveness of the use of augmented reality (WowBox AR) in the process of studying of Lewis Carroll's fairy tale "Alice in Wonderland" and "Alice Through the Looking-Glass", as well as the application of The Pumpkin's Year during the creative reading of a short story for children called "Pumpkin Year" by Ukrainian writer K. Babkina. In the extracurricular reading lesson, the model of studying E. Hoffman's work "The Nutcracker and the Mouse King" was successfully applied with the activation of the WowBox AR application. The use of interactive pages of this edition and additional bracelets contributed to the activation of readers in the virtual art world and thus the implementation of the tasks of the content lines of the program of the New Ukrainian School. In particular, within the line "Theatricalize" students had the opportunity, wearing bracelets and playing the roles of the heroes of the fairy tale, to observe unfamiliar (spectator) and to express their own (actor) expression. Thus, students were curiously involved in stage art, in which they gained experience of performance, tried to improvise. Observation of artistic expression through augmented reality, work with interactive coloring pages and stickers, expression of appropriate emotions through acting ensures the development of the child's emotional intelligence, creative thinking, initiative, self-awareness, self-control, ability to overcome barriers associated with uncertainty and risks, effectively cooperate with and understand one another.

It is becoming increasingly difficult to draw the attention of a young reader to a book in the modern conditions of informatization of society. From an early school age, children get used to gadgets, which are gradually becoming one of the leading ways of learning about the world. This problem has become even more acute in a pandemic, when the distance learning format has become more active in the education system. At the same time, we should remember the importance of the art book, reflected in the fiction aesthetic, spiritual, moral values for the formation of the personal image of the world of the student. The art of the word enriches with new knowledge, has a powerful educational potential, develops speech, figurative thinking, creative imagination and emotional intelligence, promotes awareness of national identity and socialization of the individual, causes unforgettable impressions, gives aesthetic pleasure. Therefore, there is a need to open the value of fiction for younger students, to form the interests of readers, to demonstrate the uniqueness of literary reading.

This study is devoted to the creation of an augmented reality application to the topic "Ukrainian folk tales". Due to the fact that the leading activity in primary school is gaming, the AR application for a fairy tale was created as a game-trip to the very same story. The development of the application provides for the following tasks:

- *Analysis of the work.* Describe the place and time of events, characters (motives of behavior, causes of feelings and emotions, relationships between characters);
- *Interpretation of the work.* Conduct dramatization, creative translation, continuation of the text; evaluate the experiences and emotions of the characters;
- *The emotional impact of works on the reader.* Describe the mood, feelings of the characters of the work and one's own emotions caused by reading a fairy tale; compare these emotions with the feelings caused by events in one's own life; characterize the favorite character, substantiate the sympathy, the reasons of empathy to the character.

Thus, with the help of the Unity program (Katsko and Moiseienko, 2018) and the Vuforia plugin, an augmented reality was created to accompany the creative reading of the fairy tale "Kotygoroshko" (figure 3).

The basis of the game-trip is a fairy tale map with stations and special interactive tags – circles of different colors (figure 4).

In order to activate the augmented reality on the

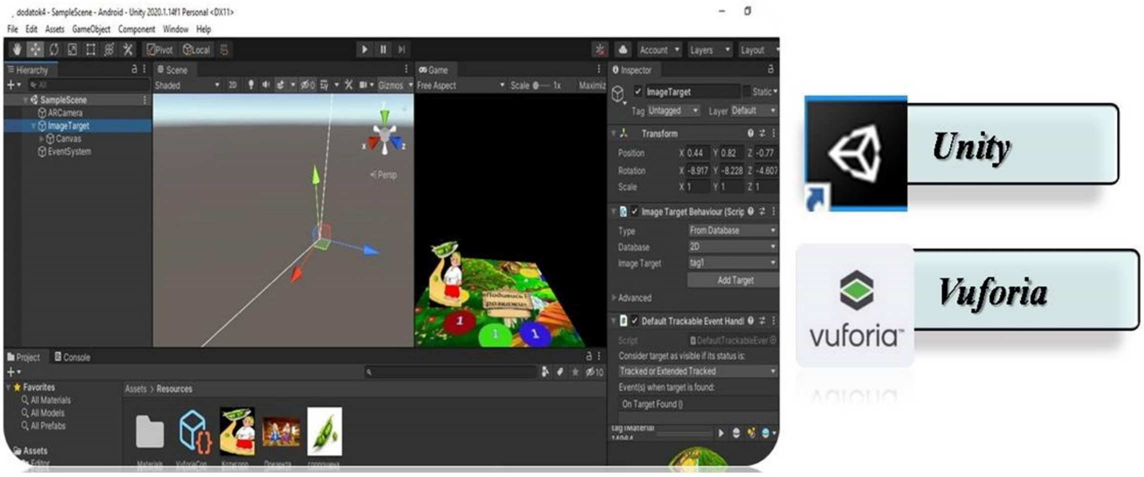

Figure 3: The process of the development of the application to “Kotygoroshko”.

Figure 4: Interactive map of the game-trip for the activation of the AR applications under the fairy-tail “Kotygoroshko”.

map and complete the lesson tasks, students form groups. For convenience, students in each group receive stickers of the same color (red, blue, green, yellow). To animate the interactive parts of the travel map (colored circles), one needs to download a specially designed AR application (figures 5, 6) on the smartphone or tablet and point the gadget to the color wheel of the command of the respective station. A specially designed program attaches a virtual AR object to the label and activates the image of the hero, the episode of the fairy tale, the text of the question on the screen. Each group of students “animates” it with the help of AR applications on each of the four stations of the circle of the corresponding color.

The first stop of the game-trip is dedicated to the retelling of a fairy tale. According to the name of the stop, it is suggested to perform the actions “Look and tell”. Each group of students “animates” the circle of the corresponding color and a fragment that needs to be transferred appeared on the smartphone. The group of students is offered the task to make a plan for the retelling of a fragment of a fairy tale visualized with the help of an AR application and to determine the speakers according to the plan. The teams were offered the following fragments: “Red” – a fragment of “Brothers and sister have disappeared”; “Yellow” – a fragment of the “Appearance of Kotygoroshko”; “Green” – a fragment of “Battle”; “Blue” – a fragment of “Betrail of brothers”.

The task of the second stop “Who is who” of the fairy-tale travel game is the characterization. Each team “revives” its hero from the fairy tale “Kotygoroshko”, watches him, remembers the text of the fairy tale and characterizes it by features: the appear-

Figure 5: Activation of the interactive part of the travel map “Look and tell”. Fragment “Battle”.

Figure 6: Activation of the interactive part of the travel map “Look and tell”. Fragment “Appearance of Kotygoroshko”.

ance of the hero; emotions experienced by a fairy-tale hero; positive and negative features; mistakes or achievements of the hero; one’s own attitude to the hero (figure 6).

The next stop of the fabulous game-trip is “Think”. At this stop, students visualize the questions based on the fragments of the fairy tale told by the students. While activating the red label, the students answered the question: What happened in Kotygoroshko? Explain why, after Olenka’s disappearance, the brothers also disappeared? Name the reasons for the return of the brothers. Why did the brothers lose the battle? What advice would you give them to win? Evaluate the actions of the brothers. While activating the yellow label, students pondered the following questions: When did Kotygoroshko appear in the family? Explain why people were afraid of his power? In what way do you think one can use Kotygoroshko’s force? Complete the preparation for the battle of Kotygoroshka and the brothers? Explain why Kotygoroshko was so confident in his strength? What would you do recommend to Kotygoroshka when he was preparing for the battle? Consider what influences the victory? While activating the green label, the students analyzed the fairy tale in the following directions: Who has Kotygoroshko met, when he came to the snake? Explain Olenka’s behavior during the meeting with Kotygoroshko? Consider whether Kotygoroshko could negotiate with the snake and not fight? Suggest possible solutions in the fight between Kotygoroshko and the snake. How do you feel about Kotygoroshko's act? Name the advantages of Kotygoroshko in contrast to his brothers. While activating the blue label, the students answered the following questions: Was Kotygoroshko able to free his brothers and sister? For what reasons Kotygoroshkodid not admit to the boys that he was a brother? Why did the brothers decide to get rid of Kotygoroshko and then freed him from their trap? Advise Kotygoroshko how to act in the situation that developed at the end of the fairy tale? What would you tell your brothers to do in the current situation? Try to model the other possible end of the fairy tale.

3 CONCLUSIONS AND PROSPECTS FOR FURTHER RESEARCH

The presented research actualizes the use of AR applications in the practice of literary education of primary school students. According to the authors of the study, augmented reality technology meets modern social and educational challenges, contributes to the successful implementation of the tasks of literary education of the New Ukrainian School, allows younger students to fully immerse themselves in the space of art and activates their figurative thinking.

Given the specifics of fiction and the leading principles of methods of teaching literary reading in primary school, this article describes the different areas of application of augmented reality in the literary field of primary education:

- visualization, observation and research of the artistic image, demonstration of its expression;
- visualization, observation and research of the artistic world of a literary work;
- organization of the reader's interaction with the literary hero;
- organization of game activities in the lesson of literary reading (study of the work with the help of a game developed by means of augmented reality);
- organization of theatrical performances with the help of interactive bracelets and stickers with AR applications.

In order to organize effective play activities of primary school students in the lesson of reading while studying a fairy tale, a mobile application (on the Android platform) of a travel game using AR technology has been developed. The development of the application provides for the implementation of the content of the current school program of the New Ukrainian School of Literary Reading: analysis and interpretation of the work, activation of the emotional impact of the work on the reader. The use of augmented reality objects in the methodology of literary reading allows the teacher to deepen the emotional resonance of reading a fairy tale, motivate to read oral folklore, develop the creative imagination of primary school children, the quality of their emotional intelligence, including the ability to understand and analyze emotions, empathy, interaction in a team, manage emotions, etc. In addition, AR applications qualitatively visualize the world of art, promote easy memorization of works by students, the development of critical and figurative thinking of primary school children in an interesting game form, their creativity and initiative.

All in all, we see the continuation of scientific research on a particular problem in the direction of studying the readiness of future teachers to apply augmented reality in the linguistic and literary field of primary education.

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Using Intelligent Agent-managers to Build Personal Learning Environments in the e-Learning System

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Keywords: e-Learning, Distance Learning, Personal Learning Environment, Intelligent Agent-Manager.

Abstract: The article focuses on the issues of developing the structure of a multi-agent environment for e-learning systems and proposes a computer technology to ensure student activities in e-learning modular systems. The relevance of the research topic is due to the low level of modern e-learning systems adaptation to the individual characteristics of the student, the lack of ability to predict learning outcomes. The technology enables to take into consideration the factors affecting the students' learning outcomes and to form an individual trajectory of the learning session from a holistic perspective.

1 INTRODUCTION

In modern e-learning systems, it is important to deliver dynamic learning materials, as well as manage the training course system in a prompt manner, that is, the e-learning system should provide the user with optimal content and encourage working in groups. An intelligent agent-manager should refer students to the most relevant community or knowledge communities, examining the materials that other community members look through, and connect students and experts (Al-Sakran, 2006).

The introduction of e-learning systems has also accelerated the evolution and the learning process in higher education institutions, given the constraints of non-adaptive systems, resulting in the introduction of new open intelligent systems that are used simultaneously with web technology. This is critical to the e-learning technology being implemented across the globe (Arif and Hussain, 2016).

Tutor agents and support systems play an important role in improving learning outcomes, as they provide continuous assistance to students in the learning process. Some of the existing learning support systems are used at the organizational level and integrated into the current organizational structure of the educational institution (Chen et al., 2003). Such learning support systems enable to connect existing users, share important information, improve the training of technical personnel, and improve organizational processes, making them more efficient. However, most existing learning support systems operate with a small number of functions that do not contribute to the development of the e-learning environment required for groups and students to achieve their learning goals in the corresponding fields (Hung and Nichani, 2001).

The main disadvantage of present-day learning management systems is the failure to provide students with assistance in the distance learning process, and therefore they are unable to replace the physical presence of a tutor, who generates the students' work progress. In fact, it is proposed to integrate for each student a metacognitive agent that would ensure metacognition assistance and reveal defects in the learning process and strategies. The goal is to encourage students to improve their learning outcomes measured against the learning goals and refine the learning method. The results show that there are relationships between different metacognitive attributes and student's academic excellence, that is, there is a dependence of metacognitive influence on learning outcomes, reflecting the degree of student's understanding of a particular training unit (Elbasri et al., 2018). There are certain difficulties associated with a large number of micro-modules and the need to form a learning trajectory tailored to the student's needs.

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One of the ways to overcome these obstacles may be the use of adaptation technology (Klašnja-Milićević et al., 2017).

Thus, the state of elaboration of this problem and current trends in the development of management systems for educational environments for e-learning are indicative of its theoretical and practical significance, and determine the urgency of the chosen theme. The goal of the research is to develop a functional architecture that supports the above goals of e-learning using mobile agent technology.

The introduction of multi-agent systems is one of the most promising areas for building virtual educational environments for distance education systems. The goal of this article is the possibility of illustrating the advantages of using intelligent agents to optimize the location and configuration of appropriate resources for distance learning courses and organizing collective collaboration in the e-learning environment.

The main objectives of the research are to develop the structure of the training service based on the use of a personal learning environment and intelligent agent-managers, which may be used to ensure individual learning. It uses a set of agents that may personalize learning based on previous requests from students (or groups of students), and improve learning and collaboration based on previous knowledge and learning styles.

2 RESULTS

As of today, the SCORM (Shareable Content Object Reference Model) standard that is a standard for sharing learning materials based on the IEEE 1484.12.1 standard model (IEEE, 2020) has been developed, and is currently being used. SCORM has been developed to ensure the multiple use of learning materials, support for and adaptation of training courses, introduction of information of individual training materials into training courses or disciplines in accordance with individual user requests. In June 2006, the United States Department of Defense established that all developments in the field of e-learning should meet the SCORM requirements. A promising direction for e-learning standardization has become the successor of SCORM – Tin Can API model (Romero, 2015), which enables to consider the types of learning activities that are not available in SCORM: mobile learning, simulations, informal learning, games; tracks events without using the Internet, and has a reliable system for maintaining the required level of security and user authentication.

When creating complicated and distributed systems, multi-agent systems (MAS) can offer a variety of solutions, especially in the field of distance learning. The combining of agent technology with other methods such as the Educational Data Mining (EDM) and Case-Based Reasoning (CBR), which in turn are based on cloud technology, is important in taking the learning process to the next level. The three-level multi-agent management architecture for distance learning in the e-learning system, which contains the following set of intelligent agents, is proposed to meet the above functional requirements (figure 1):

- Tutor Agent is a set of tools for creating rules that enable tutors to adapt the selection of learning material, define appropriate search terms for finding learning materials based on certain learning styles, and to communicate with other agents for collaboration and establish interaction between tutors and students in a distance learning system.
- Lesson Planning Agent is designed to collect information and complicated reasoning required for defining and developing a curriculum (Woolf and Eliot, 2005).
- Learner Agents are required to organize the effective interaction of students with the e-learning environment, and enable to unite various learning resources into a single whole and constantly monitor learning outcomes.
- Personalization Agents are responsible for customizing training materials based on the preferred learning style of each individual student or workgroup (Wilson, 2000).

The greatest interest for implementing LMS is represented by learning agents, which in some literature are also referred to as autonomous intelligent agents that determines their independence and ability to learn. Figure 2 shows the flow of work of an agent-manager as part of LMS, which meets the following requirements: to work in real-time mode; learn based on a large amount of data; analyze oneself in terms of behavior, mistakes and success; contain a database of examples with the possibility of replenishing it, as well as learn and develop in the process of interaction with the environment.

The objective of formalized description of modular e-learning systems to ensure the ergonomic quality of human-machine interaction has been solved. As a result, a complex of component and morphological models, which is the basis for the formation of information support to adaptive e-learning as the "man – technology – environment" classical systems and contribute to the search for ergonomic reserves of com-

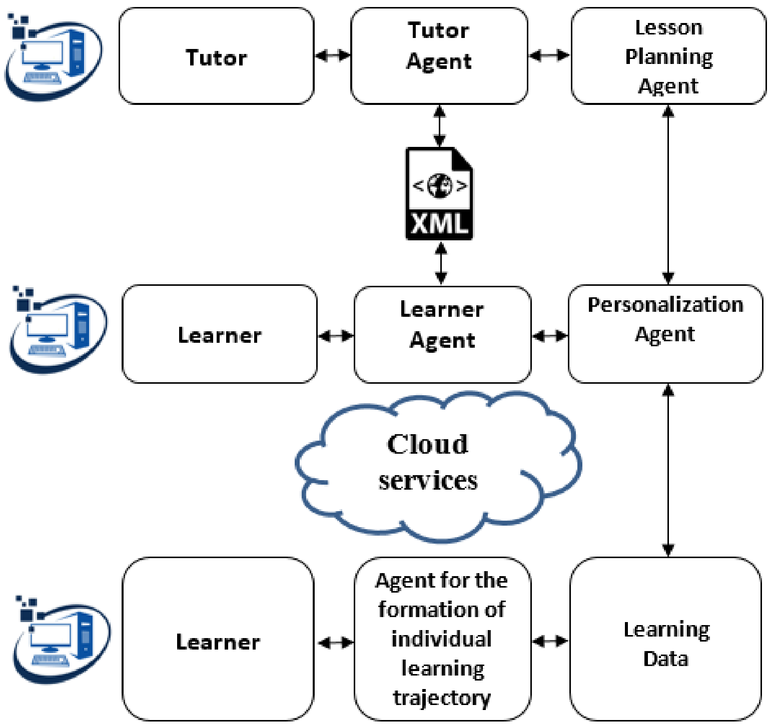

Figure 1: Architecture of distance learning multi-agent management in e-learning systems.

puter human dialogue interaction has been obtained (Lavrov et al., 2017b) (figure 1). The set of models is given by the scheme shown in figure 3, and is described by structural formula (1). The description of the designations accepted in the formula is given in figure 3.

$$\begin{aligned} MMS = <& EE, OT, PO, MODUL, KPKT, SPF, \\ & SVP, SVFS, SGOT, SMT, EREM, KvPEE, \\ & KvNpEE, KvOT, KvPKT, KvPT, MKvHEE, \\ & MFSEE, MKvMODUL, MKvMOD, ProgPPR, \\ & MDV, MUT > \end{aligned} \tag{1}$$

Here are the structures of some models.

Component model of elements of module. It describes the structure of educational module.

$$\begin{aligned} MODUL =<& [idmod_i, [PO_k, [tema_{kj}]| \\ & j \in [1,2,...,KT_k]|k \in [1,2,...,KPO], \\ & [PMod_{il}, [Srmod_{iln}]||n \in [1,2,...,KSr_{il}], \\ & [Sdmodilk]|z \in [1,2,...,KSd_{il}], \\ & Pruk_{il}]|l \in [1,2,...,KPmod_i] > \end{aligned} \tag{2}$$

where $idmod_i$ is the identification of the i-th module;

PO_k is the k-th subject area;

$tema_{kj}$ is the j-th theme of the k-th subject area;

KT_k is the number of themes of the k-th subject area;

$PMod_{il}$ is the first sub-module of the i-th module;

$Srmod_{iln}$ is the n-th self-control of the first sub-module of the i-th module;

KSr_{il} is the number of variants of self-control of the first sub-module of the i-th module;

$Sdmod_{ilk}$ is the z-th means of "finishing" of additional learning (in terms of (Adamenko et al., 1993) – "finishing") of the first sub-module of the i-th module;

KSd_{il} is the number of means of "additional learning" of the first sub-module of the i-th module;

$KPmod_i$ is the number of sub-modules of the i-th module;

$Pruk_{il}$ is a sign of existence of means of controlling the quality level (provides a possibility of changing learning technologies depending on the current level of the learning quality) of the first sub-module of the i-th module, $Pruk_{il}$ [0,1].

Component model of the means of revealing motivation levels. The model gives enumeration of means for revealing motivation levels of EE.

$$\begin{aligned} SMT =<& [INSmt_i, NameSmt_i, [PSmt_{ij}] \\ & |j \in [1,2,...,KPMT_i]|i \in [1,2,...,KMT]] > \end{aligned} \tag{3}$$

where $INSmt_i$ is the identifier of the i-th means of defining motivation of EE;

$NameSmt_i$ is the name of the i-th means of defining motivation of EE;

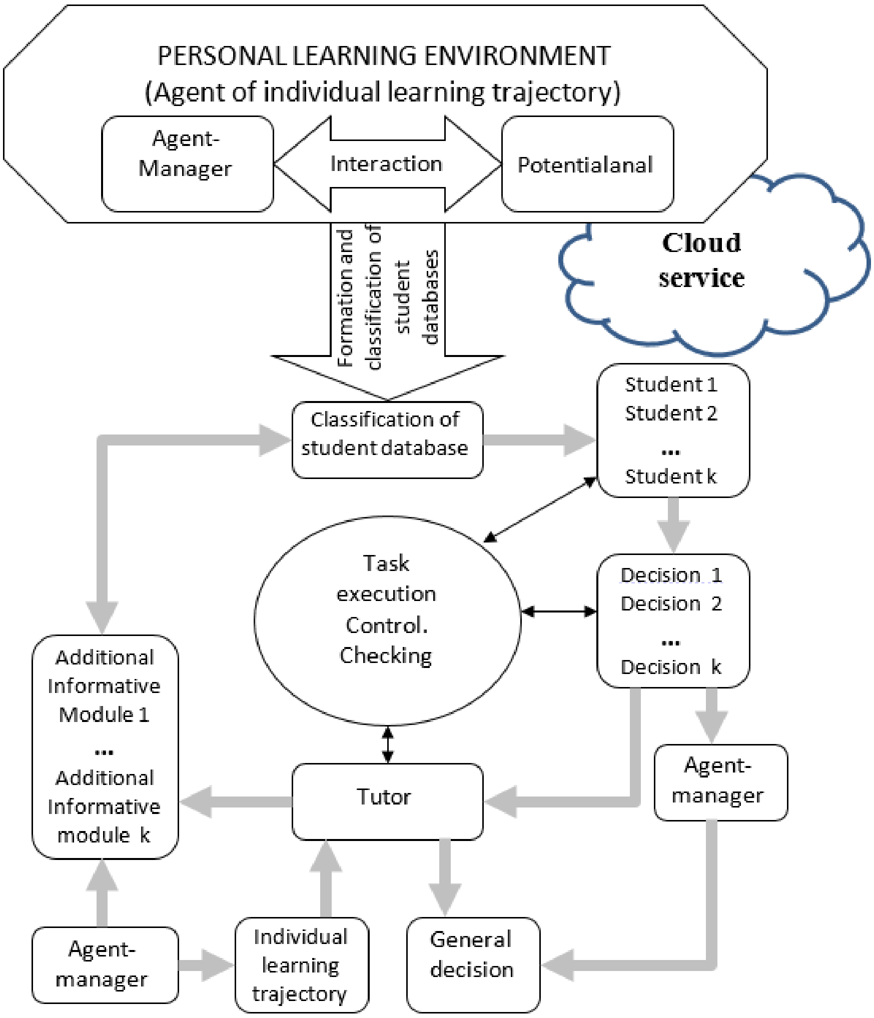

Figure 2: Flow of work of an agent-manager as part of LMS.

$PSmt_{ij}$ is the j-th indicator for the i-th means, $PSmt_{ij} \in MMT$;

$KPMT_i$ is the number of all indicators of motivation for the i-th means;

KMT is the number of means of defining the motivation level of EE.

Component model of means of revealing preferences of EE. The model describes the means for revealing preferences and indicators of EE and preference indicators of the EE, revealed by this means.

$$SVP = < INSvp_i, NameVp_i, [PSvp_{ij}] \\ |j \in [1,2,...,KPVP_i]|i \in [1,2,...,KVP] > \quad (4)$$

where $INSVp_i$ is the identifier of the i-th means of revealing the EE preferences;

$NameVp_i$ is the name of the i-th means of revealing the EE preferences;

$PSvp_{ij}$ is the j-th indicator for the i-th means, $PSvp_{ij} \in [PMOD]$;

$KPVP_i$ is the number of all indicators of the EE preferences, revealed by the i-th means;

KVP is the number of means of revealing the EE preferences.

Component-qualitative model of non-pragmatic indicators of EE. The model defines the composition of the EE characteristics, which are revealed for defining individual preferences, psycho-physiological characteristics, functional state, motivation and level of readiness for learning.

$$KvNpEE = < [PMOD, PFH, [PFS, VPfs], \\ [MMT, VMmt], [InUGot, VUGot]] > \quad (5)$$

where $PMOD$ is the set of characteristics of preferable modalities of the EE;

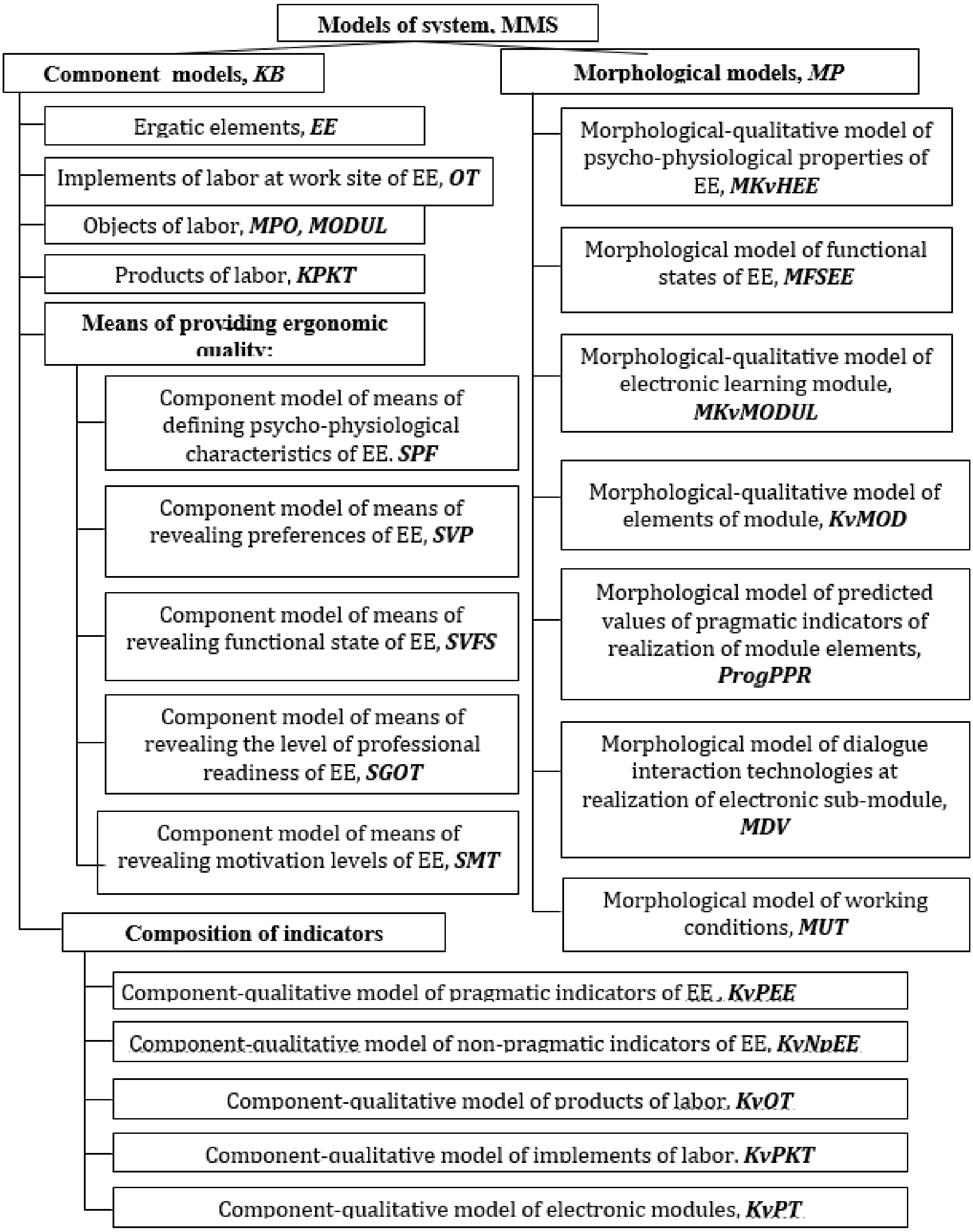

Figure 3: Structure of complex of models of systems ergonomic analysis.

PFH is the set of psycho-physiological characteristics of the EE;

PFS is the indicator of functional state;

$VPfs$ is the range of values of functional state;

MMT is the level of the EE motivations;

$VMmt$ is the range of values of motivation level;

$InUGot$ is the integral level of professional readiness for learning of EE;

$VUGot$ is the range of values of the level of professional readiness for learning of EE.

The set of characteristics of preferable modalities of the EE are determined by formula:

$$PMOD = < [Pmod_j, VPmod_j] | j \in [1,2,3,4] >$$

where $Pmod_j$ is the name of the j-th characteristic of preferable modalities of EE;

$VPmod_j$ is the range of values of the j-th characteristic of preferable modalities of the EE.

The set of psycho-physiological characteristics of the EE is determined by formula:

$$PFH = < [Npfh_j, Vpfh_j] | j \in [1,2,...,Kpfh] >$$

where $Npfh_j$ is the name of the j-th psycho-physiological characteristic of the EE;

$Vpfh_j$ is the range of values of the j-th psycho-physiological characteristic of the EE;

$Kpfh$ is the number of psycho-physiological characteristics of the EE.

Component-qualitative model of implements of labor. The model describes the characteristics of implements of labor, used in the system.

$$\begin{aligned} KvOT = &< [idOt_i, NameOt_i, TipOt_i, [Pk_{ij}, Val_{ij}] \\ &| j \in [1,2,...,KPK_i] | i \in [1,2,...,KOT]] > \end{aligned} \tag{6}$$

where $idOt_i$ is the identifier of the i-th implement of labor;

$NameOt_i$ is the name of the i-th implement of labor;

$TipOt_i$ is the type of the i-th implement of labor;

Pk_{ij} is the j-th characteristic (quality indicator of the i-th implement of labor);

Val_{ij} is the value of the j-th characteristic of the i-th implement of labor;

KPK_i is the number of all quality indicators of the i-th implement of labor;

KOT is the number of implements of labor.

Morphological-qualitative model of electronic learning module. The model contains the values of the results of ergonomic assessment of learning module quality.

$$\begin{aligned} MKvMODUL = &< idMod; [PO_k; [tema_{kj}]| \\ &j \in [1,2,...,KT_k]; [px_i] | i = [1,2,3]; \\ &[py_i]| = [1,2]; [pz_i] | i = [1,2]; [pv_i] | i = [1,2,3]; \\ &[pm_i]; [mod_i] | i = [1,2,3,4]; e_i | i \in [1,2,3]] > \end{aligned} \tag{7}$$

where $idMod$ is the identifier of a module;

PO_k is the k-th subject area;

$tema_{kj}$ is the j-th theme of the k-th subject area;

px_i is the $i-th$ indicator of the interface assessment;

py_i is the $i-th$ indicator of assessment of slide's parameters;

pz_i is the $i-th$ indicator of test assessment;

pv_i is the $i-th$ indicator of assessment of visual environment;

mod_i is the $i-th$ indicator of information modality;

e_j is the result of assessment (resolution on correspondence of a module to ergonomic requirements).

The developed models defined the concept of building databases and knowledge of the learning management system in the software package “Agent – Manager for e-learning” (Lavrov et al., 2017a). Each module can also be divided into parts (submodules), depending on the levels of complexity of the training material. The individual learning trajectory is a sequence of e-learning modules(ELM) and self-monitoring procedures. Individuality of the trajectory of learning is achieved through the use of different types of self-control procedures. Self-monitoring is a test procedure performed by a student after studying part of the module. UML-diagram of options for using the software package ”Agent - Manager for e-learning” is shown in figure 4.

To study the effectiveness of the developed models and computer technology, the experiments were conducted on the basis of Sumy National Agrarian University. The quality expertise and evaluation of the parameters of electronic training modules “Informatics” for first-year students of the specialty “Agronomy” of the Bachelor’s educational level were carried out.

The developed technology makes it possible to take into account the factors affecting the students’ learning outcomes from a holistic perspective and form an individual trajectory of the learning session.

3 CONCLUSION

The proposed architecture of the training service based on the use of a personal learning environment and intelligent agent-managers provides users with the opportunity to collect, analyze, distribute and use knowledge in the e-learning system from various independent sources.

The computer technology that enables to automatize the processes of organizing high-quality human computer interaction in e-learning systems has been developed:

- ensuring a focus on comprehensive accounting of factors affecting the students learning outcomes;
- automatic selection of an individual training session trajectory.

The direction for future research:

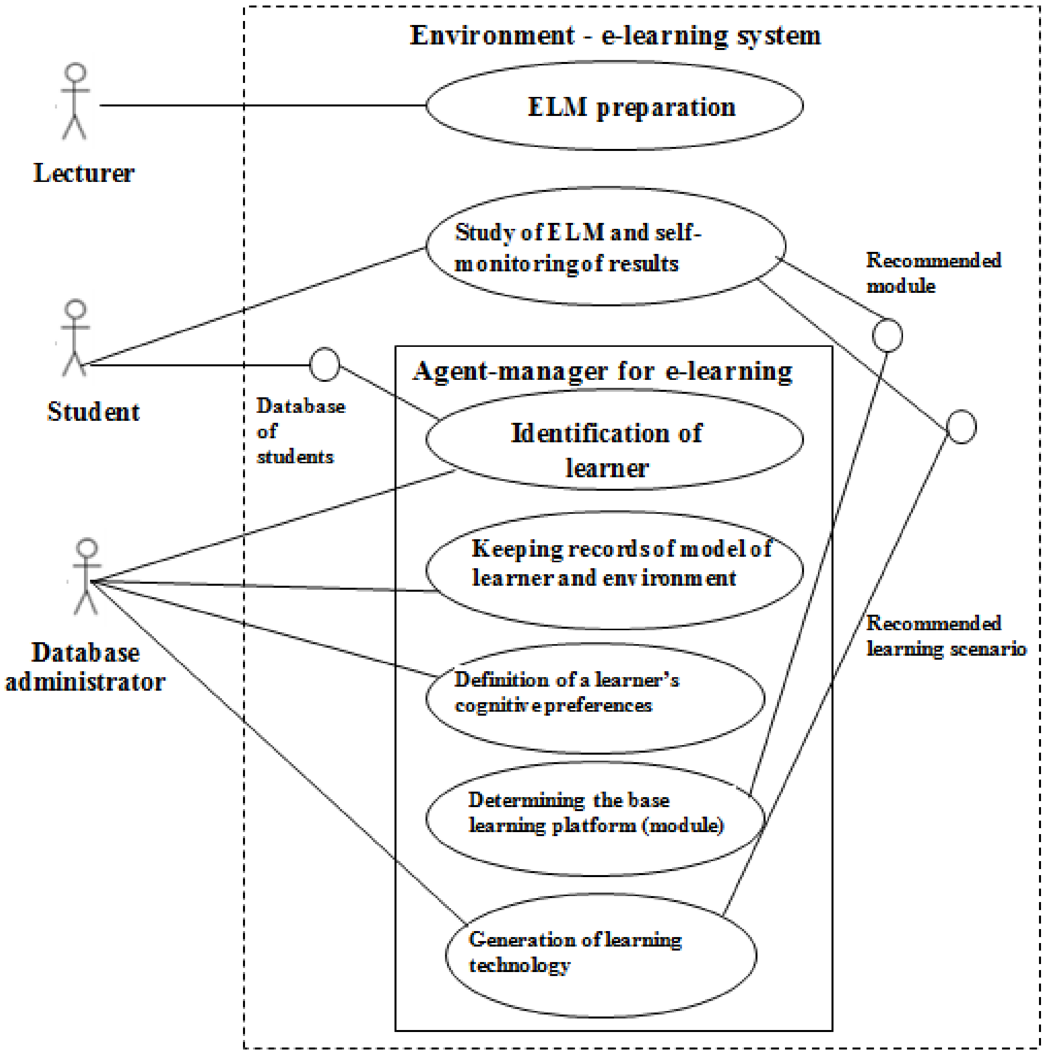

Figure 4: UML Use Case Diagram of agent-manager for e-learning.

- development of intelligent agent models based on dynamic data extraction rules and interaction with LMS;
- formation of intelligent agent operation algorithms that automatically detect the student's status, profile, and agent response in real time.

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Digital Twin of an Educational Institution: An Innovative Concept of Blended Learning

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Keywords: E-Learning, Blended Learning, Digital Twin.

Abstract: The actuality of this work lies in the fact that it features and singles out the problems occurring in organization of educational process during the period of forced breaks and formed needs of information society. It highlights the necessity of introduction of blended learning used to support the educational process continuity and to ensure the formation of motivation and interest of students/learners in process of knowledge acquirement. It shows the need to update the educational environment in conditions of digital prototype of educational institution, created in order to provide quality knowledge and ability to build an individual development trajectory for each learner. For the first time the use of state-of-the-art Digital Twin (DT) technology has been proposed to build a digital prototype of educational institution. It is shown that this technology is quite actively used in various fields. An analytical review of successful DT practices and clarification of problems caused by COVID-19 quarantine leads to the conclusion that DT can be used effectively in slowing down and limiting the spread of the disease, as well as preparing for possible long-term disruption of school attendance by learners. It is assumed that the usage of DT for each educational institution requires the creation of authentic digital environment (web environment) aimed to support the educational process in blended learning format and based on integration of traditional teaching aids and digital resources. It is justified that the involvement of DT in education will logically combine physical and digital spaces as well as functional components of each educational institution and create their digital prototypes, which will actually function as dynamic and open web resources. DTs open to all participants of educational process the opportunity to obtain quality results in any circumstances that may be dictated by the society, while maintaining the integrity of educational system and pedagogical values of each educational institution.

1 INTRODUCTION

The experimental process of urgent introduction of distance learning technologies in 2020 became global, with forceful involvement of educational institutions (EI) all over the world quickly entering the digital world. It is already clear that this process has launched an innovative path in the development of educational systems in all countries. In the nearest future, distance learning in various formats will be improved and gain capacity. Which, in turn, will lead to changes in popular traditional teaching methods and approaches or to total reformation of educational systems in general – digital technologies (DT) continue to transform modern classrooms, teaching methods change according to expectations and learning styles and interests of students/learners.

Referring to DT potential in the field of improvement of teaching and learning, alongside with increasing access to information and data management coordination, the researchers claim that rapid changes will force most EIs to either adapt or cease to exist (McCluskey and Winter, 2012).

Analytical research shows that forced disruption of educational process caused by COVID-19 quarantine has become a powerful stress-test for educational systems around the world; this disruption, as a "vor-

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tex" event, also gave them the impulse to elaborate alternative long-term education development plans. After all, we realize that the educational process and cooperation of its participants may no longer be carried out in the traditional format. It is known that the COVID-19 pandemic has closed educational institutions around the world, and the UNESCO report dated March 18, 2020 stated that "more than 899 million young people were affected" (Otsu, 2020). It is noteworthy that as of March 24, 2020 various countries have already developed the emergency plans including the following:

- continuous provision of information and training related to virus spread and impact (France, USA, Italy);
- creation and training of working groups consisting of counselors and teachers to support parents and pupils / students (USA);
- deployment of online classes (China, Singapore);
- training of teachers and directors (EI) for remote work (Italy, United Kingdom, China).

Some countries, as soon as in March 2020, have provided for future backup plan of educational institutions closure, both at the national level (e.g. China, Italy, Korea, Japan), regional level (e.g. France, Germany, Portugal, Spain) and narrow specialization level (e.g. USA, United Kingdom). The Estonian Ministry of Education put forward the idea of cooperation with neighboring countries and free exchange of information resources on the Internet with the world. With participation of three Baltic States, Latvia and Lithuania, as well as northern Denmark, Finland, Iceland, Norway and Sweden, more than 40 online learning solutions were collected. At the end of March, there was also held a webinar for parents from Estonia on the subject how to approach home schooling organization (Otsu, 2020).

It is clarified that higher education institutions in almost all countries of the world are the most provided with Internet materials and electronic educational resources (EER), as many of them have provided distance education services using online courses in the last decade. As an example, we can cite the following resources:

- powerful electronic database of educational and scientific materials of Duquesne University (guides.library.duq.edu, 2020);
- resources for teaching on the Internet Institute of Food Technologists (www.ift.org, 2020) (USA);
- resources for teachers and researchers (Japan) (Toho University media center, 2012);
- ezines, ebooks and databases to which Osaka University attracts other universities (Osaka University Library, 2012), Kyoto University provides university staff with ezines (about 40,000 titles), ebooks (about 50,000 titles) and databases (about 100 types) (Kyoto University Library Network, 2016) etc.

However, all above mentioned cannot be systematically and in full volume attributed to primary and secondary education. That is why there is an urgent need to address this issue as an explosive problem.

2 COVID-19 AS THE DRIVER FOR BLENDED LEARNING

We have found a number of new solutions to solve the problem of learning disruption, such as:

- Assistance to the Malala Foundation – it helps to shape global and national responses to the COVID-19 challenge, which in some particular countries are manifested in the following formats (www.malala.org, 2020):
  - Nigeria – Cooperation with school teachers and education authorities has been intensified with the purpose of implementation of radio program that broadcasts school lessons, including reading, writing and STEM. Radio program helps Nigerian children who do not have access to Internet resources to learn on the radio.
  - Lebanon – the following digital educational solutions are offered: development of digital lessons on the basis of state program in the scope from kindergarten to high school; these lessons are now available to everyone on the Internet. These solutions also provide training for teachers helping them to conduct interactive classes at a distance.
  - Pakistan – there has been developed a digital application called Taleemabad, which digitizes Pakistan's national curriculum. Taleemabad broadcasts cartoons of standard lessons for all who cannot attend EI. In order to respond to growing demand caused by the pandemic and to cover at least one million pupils / students across the country, Taleemabad is expanding its national curriculum and broadcasting lessons through the educational television program.
- Northern Macedonia – access to new digital platform with video classes and game-based learning activities for usage by teachers of primary, vocational and higher education institutions has

been made available in shortest possible terms (eduino.gov.mk, 2021).

An analytical review of educational process organization experience in conditions of COVID-19 spread shows that educators in many countries began to develop and implement emergency plans quite quickly. It is clarified that the managers of educational sectors are aware that in current conditions various forms of Internet education an EER development and use should be mobilized. In general, EER are aimed at slowing down and limiting the spread of the disease, as well as at preparation for possible long-term disruption of EI attendance by the participants of educational process. As UNICEF spokeswoman Patricia Di Giovanni said in spring 2020: "Our teams have been working day and night during past two weeks to find a solution to ensure that children's right to education is not violated by a new measure to prevent the spread of coronavirus in the country" (UNICEF, 2020).

Due to intensification of anti-epidemic measures, the pupils in Ukraine have been prohibited to attend schools from January 8 to January 24, 2021, at the same time EI have been entitled to announce vacations for this period. It is already known that at this time the educational process was carried out in remote format, while in future it is planned to continue training in traditional full-time format. However, no one can guarantee the use of only one format (full time or remote) even in the nearest future. As the experience of 2020 has shown, educational institutions must be organizationally and methodically prepared for the transition to one or another format, without compromising the quality of educational process. According to (Holiver et al., 2020; Kukharenko and Oleinik, 2019; Spirin et al., 2019; Vlasenko et al., 2021; Zinovieva et al., 2021), one of the options to be chosen for realizations of this problem can be readiness for introduction of blended learning. We believe that this format of learning organization quite effectively combines the advantages of traditional learning with distance learning. As it has been found, the term "blended learning (hybrid learning)" has different definitions in literature. In general, it is a combination of offline and online learning in various proportions. The concept emerged in the 1990s as a counterweight to online learning (blog.ed-era.com, 2019).

Caraivan (Caraivan, 2011) grounded that blended learning involves the use of two or more different teaching methods, i.e. a combination of methods that meet the needs of pupils / students, regardless of the subject they are studying. It may include such combinations as:

- traditional training sessions with online learning;
- online instruction with access to the teacher;
- modeling with structured courses;
- on-the-job training with some informal classes;
- management coaching with distance learning activities.

At the beginning of the XXI century, the concept of blended learning appeared in discussions about education, at the time when the concept of distance learning began to lose its credibility. In conditions of distance learning format, students were not highly motivated and independent; they felt isolated and unsupported by teachers during their studies. Thus, there was determined a necessity to find new conceptual approaches allowing to avoid obligatory changes in distant learning and to provide a supplement for it (Caraivan, 2011).

Jarman (Jarman, 2019) give several reasons why blended learning should be used:

1. *Obtaining qualitative results of learning.* As confirmation, we use the results of the study conducted at the Iowa University: 95 % – best performance rate of students who studied in blended courses section; respectively 82 % – in sections of lecture halls and 81 % – learning on the Internet only.
2. *Encouragement and growth of pupils / students independence*. Using distance learning, students learn to set and manage personal learning tasks. In addition, blended learning contributes to their academic responsibility while maintaining the control needed for support. As blended learning uses online programs, students can learn at their own pace and according to their personal level of understanding and perception of information, thus building an individual learning trajectory.
3. *Preparation of pupils / students for functioning in conditions of society focused on DT.* Thanks to integration of DT teachers have the opportunity to ensure better preparation of students for future professional careers and civic life..
4. *Reduction of training costs.* From an administrative point of view, blended learning is a good investment because it maximizes the saving of costs obtained in the result of online learning. Blended learning can reduce the need for EI facilities, their repairs and maintenance. Reduced workload of teachers may result in achievement of higher ration of teacher-to-student communication and more efficient use of time.
5. *Improving the effectiveness of cooperation.* pupils / students can meet with teachers and other pupils

/ students whenever and wherever. At the same time educators can find better ways to cooperate. Teaching in a team mode is much easier in online environment, where everyone gets the flexibility to work on their own schedule.

6. *Formation of interest and motivation to study.* Nowadays some students find online programs and software more interesting than standard full time sessions. Blended learning can break the monotony of the traditional classroom by introducing information and concepts into different contexts. Of course, DTs can be a distraction, but they can also present information in new and exciting ways, including interactive software, 3D animations, and video games.

We see it necessary to add that blended learning can take the first place among other formats and become popular and necessary in the nearest future.

Given the prospects of blended learning as an innovative model of education, which is relevant not only in the period of quarantine restrictions, we emphasize the specific features of educational process management during its implementation.

In conditions of blended learning the organizational accuracy of educational process which is provided in management through change of educational process schedule, acquires a special value. In conditions of stable functioning EI can determine the periods of distance and full-time training, their sequence and duration. Under conditions of quarantine restrictions, periods of distance and full-time training may be held not under schedule, but spontaneously, depending on the epidemiological situation. Therefore, one of the first managerial tasks is to establish an accurate schedule of educational process and provide recommendations to its participants on actions in case of unplanned changes.

In management of blended learning, communication between managers, teachers and students is changing. It cannot be the same in at full-time training, as the possibilities of direct contact are limited. This necessitates the definition of methods and resources for communication to solve a set of tasks of various levels and orientations. In particular, during periods of distance learning the main focus is placed on communication between teachers and students both in course of educational process and in format of individual work, tutoring, counseling, mentoring and more. Communication between managers and teachers, as well as between teachers themselves, can take place both in face-to-face and remote mode at all stages of educational process.

The next factor influencing the management in conditions of blended learning is the necessity to change the scientific and methodological support of educational process. Educational content is being changed and updated in view of peculiarities of full-time and distance learning, respectively, the programs, training materials, learning evaluation criteria for students etc. require consequent adaptation. We can say that at present stage of blended learning introduction the problems of scientific and methodological support are becoming relevant (definition and structuring of content, teaching methods, assessment).

Thus, blended learning leads to changes in management of educational institution-digital twin in three main areas: educational process organization, its scientific and methodological support and communication between its participants.

3 DIGITAL TWIN OF EDUCATIONAL INSTITUTION

The format of blended learning introduced in EI digital twin should open the possibility for unimpeded transition from traditional to distance learning and vice versa. This is explained by the fact that in order to prevent EI closure, it is but natural to suggest that teachers should use digital tools to complement the traditional format of teaching. After all, according to experts, “every week of EI closures leads to considerable losses in development of global human capital with significant long-term economic and social consequences. Accordingly, the governments and Education Ministries of many countries have already developed plans that summarize the following items” (OECD, 2020):

- *Use of existing online distance learning platforms – learning management systems (LMS).* It is important that at present online platforms can incorporate training courses and resources in digital formats (text, video lectures, etc.), usually with a bank of relevant EER. Typically, teachers can select lectures and exercises assigning them to students for usage through synchronous lessons. In educational institutions where such platforms do not exist, open EER can similarly be used.
- *Development of new open online educational platforms (virtual classrooms)* – teachers can remotely teach their pupils / students while they are at home, using various platforms. Some “virtual audience” services already exist within countries, and they have been located in China and Singapore, regardless of ownership type.
- *Partnership with private educational platforms* – one of identified difficulties in usage of existing

EERs is that their mass simultaneous use is not always possible. In order to empower educational institutions, some platforms belonging to private sector have already opened their own EERs with free access just at the beginning of global quarantine (for example, in China and Japan (Saiki, 2020)).

- *Cooperation at the international level for consolidation of existing online EERs* – although educational institutions in different countries, and sometimes some regions (states) within the same country, have different curricula, they usually teach similar disciplines and that is why it is possible to consider the potential for the organization of distant learning which consists in translation and use of foreign EER and digital resources, respectively, coordinating them with authentic curricula.
- *Use of all necessary electronic means* – return to usage of some obsolete electronic means, such as television or radio broadcast lessons, for regions where the infrastructure is low.
- *Providing teachers with digital learning opportunities* – educational policies should be aimed to provide continuous assistance to teachers in mastering of online teaching methods (for example, as has been done in Italy). Such activities can be carried out through open web platforms designed for sharing with possibility of exchange of author's developments – EER.

At the same time, forming responses to possible necessity of EI closure, educational policy makers should consider ways to:

- care for the emotional health of pupils / students;
- making necessary technological decisions to ensure continuous relationships between all participants of educational process, their interaction and support of teachers in teaching process;
- providing access to devices – pupils / students should have access to technical equipment; respectively it is necessary to start projects to provide devices or provide alternative resources (printed workbooks) (for example, as it is done in the UK (www.gov.uk, 2021a,b));
- IT infrastructure access management – simultaneous connection of all pupils / students can be problematic in some regions of their residence, so access to IT infrastructure should also be controlled to ensure the quality of education for all, perhaps even be regulated by way of setting certain time limitations;
- balancing traditional and digital approaches used in educational process replacement of traditional forms of learning by digital format is likely to affect both the health of students and the quality of learning outcomes; it is logical to reduce duration and number of lessons / classes and their combination with digital educational formats;
- security of web systems used in exams – exams often require strict identification of pupils / students; Appropriate technological and software solutions already exist for face recognition; introduction and use of these aids must be extended.

Thus, the explosive wave of urgent EI closures offered educators the opportunity to experiment, to develop and to implement new models of educational systems and new approaches to distribution and use of learning time. Educational institutions must be prepared to provide quality educational services, they have already faced a difficult choice of how to get prepared for blended learning.

From now on, and in view of present circumstances, education managers around the world need to create a model of updated educational environment. They should answer the question: how to help educators to get prepared for execution of quality professional activities and provision of quality educational services in updated educational environment?

The digital twin of EI is actually an updated educational environment. The process of digital twin functioning must be based on the same managerial principles as actual EI, but in view of specific features of virtual environment and digital technologies. The functioning of digital twin cannot be seen, but it is possible to take part in it and perform the same functions, to act, to achieve tasks, to get real results. To exercise the management of digital twin, EI uses a modeling method that allows to present the main subsystems and processes of real EI in the form of schemes and models; it is done in order to select digital resources for appropriate support in cyberspace, and on this basis – to involve the participants of educational process in these activities. Thus, EI will exist and function in two dimensions – real and virtual. Thus, the task of management is to model a virtual reality of an educational institution. When creating a digital twin of an educational institution, the management should focus on common strategy: in virtual dimension there must function the same educational institution as in real life, which ensures full implementation of all functions and has clear structure.

Management process of EI digital twin includes the components, similar to those of real EI: strategic, organizational, financial management, personnel management, infrastructure management, marketing of educational services, operational management. These components are described below:

- strategic management – determining the strategy for the development of EI digital twin, blended learning, as well as criteria for achieving planned results;
- organizational management – ensuring the activities of EI digital twin, medium-term planning, coordination of structural units activities, monitoring the condition of subsystems, analysis of their activities;
- financial management – EI cash flow control, cash flow directing to achieve certain goals, minimizing risks;
- personnel management – selection of personnel, personnel preparation for implementation of tasks related to blended learning, personnel professional activity in conditions of EI digital twin functioning;
- infrastructure management – creation of material and technical base to ensure the functioning of EI digital twin, creation of comfortable working and learning conditions, accessibility for all participants of educational process;
- marketing of educational services and PR – promotion of blended learning in the market of educational services, meeting the educational needs of consumers, communication with general public in order to create positive perception of distance and blended learning, quality assurance of educational services;
- operational management – short-term planning and solution of current problems related to EI functioning.

It is seen that first of all there must be formed a digital environment (web environment) of each separate EI, the conditions of this digital environment should provide for the implementation of educational process in mixed format, based on integrated use of traditional tools and Internet resources. In turn, the pedagogical community from now on must think about development of innovative organizational and methodological approaches to be used for provision of educational services in web environment. The conditions of above mentioned EI web environment should be formed in view of equal access to knowledge for all participants, in accordance with personal needs and qualities. After all, according to Caraivan (Caraivan, 2011), "The environment is a mixture formed by mass media and various methods leading to interactions. Educational experience is based on memorizing interactions and practices exercised during interaction, so that communication is, in fact, the main "ingredient" of the mixture".

Performed scientific researches demonstrate realizations of various authors, where the "Digital University" concept is the most remarkable.

The authors' understanding of "digital university" phenomenon is based on the conceptual "matrix" consisting of four components: digital participation, information literacy, learning environment, curriculum and courses design. According to the authors, none of these components can be considered new if regarded separately, but their combination and analysis of their interrelations provides a holistic way to understand the digital university (Rowell, 2019).

- *Digital participation* – provides for involvement of university societies to spread the idea of universities being a public good for the whole society.
- *Information literacy* – stands for the idea that students develop digital literacy skills in order to improve their academic potential and opportunities for personal development.
- *Learning environment* – means a combination of digital and physical spaces that exist within and outside the university; it is more than just a virtual learning environment of EI.
- *Curriculum and course design* – these are formed through "constructive coordination", evaluation and transition to the latest developments, such as digital analytics.

McCluskey and Winter (McCluskey and Winter, 2012) offer thesis: "Digital University is fundamentally different from traditional university". Declaring this idea the authors put forward their thesis that education must change in response to growing demands for public accountability. Researchers claim that this goal can be achieved by the usage of advanced DT capacities.

There are many examples of digital universities functioning in educational space of various countries. For example, "universities and educational experts from Germany, Austria, Russia, Georgia and Ukraine are actively involved in international cooperation: they have established the International Digital Network University, thus laying the basis for education to function by way of crossing the borders between the countries. According to the portal, "Network University is a virtual association of universities and higher education institutions created for long-term cooperation. Participating educational institutions provide online training courses certified by the European System ECTS, are recognized by all network partners and can be taken by students as electives". The most important task of network university is to promote mutual comprehension. This is being achieved through structured intercultural exchange and joint development of educational proposals in the fields of education for constant development, inter- or transculturalism, conflict prevention and peace-seeking, as well as proposals for integrated subject-language learning in German CLILiG (Content and Language Integrated Learning in German) (www.goethe.de, 2019). The network university includes:

- University of Bremen;
- Virtual Academy of constant Development (Germany);
- Ruhr University in Bochum (Germany);
- Viadrina European University in Frankfurt on the Oder (Germany);
- Kazan Federal University (Russia);
- Tyumen State University (Russia);
- National Research University “Higher School of Economics” (Moscow, Russia);
- Ilia State University (Tbilisi, Georgia);
- Mariupol State University (Ukraine);
- Vienna Higher School of Agricultural and Environmental Pedagogy (Austria).

However, according to the author’s concept, there is a necessity to develop not only digital IE (universities, schools, gymnasiums, lyceums, etc.), but, for the most part, digital prototypes of real educational institutions.

The analytical review of digital innovations showed that one of the 10 best strategic trends determined by the research and consulting company Gartner Inc. in 2017 is a digital technology called digital twin (DT-technology) (Ismail, 2019; Deloitte University Press, 2017). The digital twin concept is based on the idea of the convergence of physical and virtual worlds, where each object receives its own dynamic digital representation (imprint). DT tools include powerful components such as big data, Internet of Things, machine learning and artificial intellect, which are primarily used in industry. Wide access and use of these tools have made DT more cost-effective and accessible for the business world, including, in our view, the educational sphere as well.

According to Mussomeli et al. (Mussomeli et al., 2020), “digital twins are multiplying as their capabilities and sophistication grow. But full-fledged realization of their promises may require the integration of systems and data into entire organizational ecosystems”.

It was found that DT is increasingly used in advanced industries to achieve various goals. According to research conducted by the Deloitte company, DT technology is spreading rapidly in industries such as aerospace, retail, healthcare and others. In industry, DTs are used to optimize operation and to provide maintenance of physical systems and production processes, where digital twins are understood as digital copies of physical models with possibility to observe their behavior (both digital and physical format) simultaneously in real time mode. Developed DTs allow to visualize objects or to be used for evaluation of technological solutions. Digital representation of objects provides for both development of individual elements and functioning dynamics of its physical analogue. In the industrial sector, there are too many digital twins (equipment, systems, separate machines, or even enterprises) which are developed before the startup of large-scale and high-speed production (skelia.com, 2020). That is, DTs can imitate any aspect of physical object or process. According to the Deloitte report, the global market of DT technologies will reach the point of $ 16 billion by 2023 (Mussomeli et al., 2020). We have identified several definitions for the term “digital twin” (Ismail, 2019; Gartner, 2020):

- digital representation of real object or system;
- software analogue of physical device simulating internal processes, technical characteristics and behavior of real object under the influence of interference and environment;
- fundamental technologies evolving and covering physical and digital spheres and make it possible to obtain increasingly important digital results;
- digital copy of living or non-living physical object;
- digital replica (imprint) of potential and actual physical values, processes, people, places, systems and devices.

Researchers suggest the following classification of DT (www.it.ua, 2020):

- *Digital Twin Prototype (DTP).* The DTP duplicate contains the information needed to describe and create physical versions of real objects; this information includes geometric and structural models, specifications, and conditions, as well as cost model, calculation (design) and technological models of the object. A DTP duplicate can be considered as conditionally constant virtual model of the object.
- *Digital duplicate instances (Digital Twin Instance, DTI).* DTI of object describes a specific

physical instance to which duplicate remains associated throughout its life. DTs of this type are created on the basis of DTP-duplicate and additionally incorporate production and operational models which include history of work production, applicability of materials and accessories, and also statistics of failures, repairs, replacement of assemblies, aggregates, etc. Thus, the DTI-duplicate of the product is subject to change in accordance with changes of physical object in process of operation.

- *Digital Twin Aggregates (DTA).* DTA is defined as an information system for management of physical instances related to family of objects; it has access to all of their DTs.

According to classification given above, each type differs in functionality, complexity and technologies integration level. In summary, we can conclude that DTs can be divided into digital models of system, certain line and separate component of certain line. Digital twins can form connections between all objects of real physical system and enable cooperation in the team/teams and interaction between teams. While functioning in DT mode, you can create, assign, and track tasks meeting business priorities and needs of real facility. We can single out the reasons of sudden demand for digital twin technologies (Ismail, 2019):

1) they bring considerable value to business and become essential for digital strategies;
2) the rapid growth of digital technologies introduction is explained, in particular, by active marketing and organization of training performed by their suppliers.

Nowadays, given that DT technologies have rather strong support from IT giants, including IBM and SAP, various companies have already paid close attention to digital technologies. Already now, in times of forced quarantines, it has been reported that many well-known companies have ensured the efficiency of continuous production process in conditions of their digital twins.

An important feature of digital twin is that its functioning as a model or as a system is possible in both online and offline modes. For the purpose of presentation and improvement, the functionality of DT is constantly updated from several sources (Deloitte University Press, 2017). For example, in marketing activities, virtual avatars can provide tours for visitors interested in DT real estate. Accordingly, in real time mode, visitors can provide feedback and put questions to the owners. DT also allows to organize training for new employees for the performance of their professional duties and usage of equipment, regardless of their location in the world.

As mentioned above, DT technology is spreading rapidly in various fields and, ultimately, according to the author's vision, should affect education. Already in 2019, Gartner included the concept of Digital Twins in the TOP-10 list of technological trends and predicted that "in the near future, there will exist digital twins for billions of things" (Ismail, 2019). Over time, the DT trend will evolve and expand – individuals, teams, services, businesses and even cities have or are in process of formation of their digital twins. So, in the coming years DT technologies can be expected to be widely deployed in education as well. Given the specifics and qualities of DT, we can assume that their qualities, combined with development of Internet powers, will open opportunities to monitor, control and optimize the educational process in EI both in distance and full time traditional format, as well as to use their integration form – a mixed format.

Due to fast interactive feedback, the emergence of EI digital twin will help to develop innovative solutions of complex educational problems – in particular, to build an authentic innovative educational web environment for each separate EI. After all, the benefits offered by DT can provide many opportunities which are not available in physical educational space of educational institutions. Nowadays, when educational institutions have to learn to work virtually, digital twins can become the only opportunity to create EI web environment with comfortable conditions for the development of all participants of educational process and for provision of quality educational services in blended learning. We acknowledge the possibility and the necessity for building of EI digital twin, using EER and LMS as a basis, in view of their capabilities to support the entire life cycle of educational institution. After all, DT-technology, taken as digital dynamic resource, can ensure the creation of "digital" or virtual "building" inside the educational institution and provide for the following:

- to combine previously incompatible systems, resources and formats in order to gain new insights, optimize management of educational process and remote monitoring;
- to plan and implement a sequence of production tasks and find ways to distribute them among the performers;
- to provide influence at organizational level – for EI managers there appear opportunities to develop planning of all production processes in advance and to manage them remotely;
- to provide control and monitoring of teachers'

workplaces and conditions of real educational environment, thereby improving the experience of EI administration staff;

- to minimize the presence of participants of educational process in EI facility and protect them from possible risks.

It is seen that in the "walls" of EI digital twin there should be integrated all the traditional components of educational process and digital resources used in teaching. The main feature of EI digital twin is the possibility of continuous updating in accordance with changes in its educational and technological contents, as well as in accordance with development of digital technologies in general. According to the author's vision, EI digital twin, as an integral web resource, should include all its real components in digital format:

- means of educational process organization;
- EI structure (classrooms, study rooms, electronic library, administration offices, teachers rooms, rooms for methodologists, psychologists, etc.);
- teams (groups) of participants in educational process;
- total amount of workload and expected learning outcomes of students;
- list, content, duration and interconnection of subjects, disciplines, etc.;
- description and tools of internal system of education quality assurance;
- teaching aids;
- means of technological and technical equipment;
- nomenclature and technologies used;
- system of collection and storage of educational and methodical information – web library;
- other educational components (by decision of EI administration).

The more efficient technological systems and resources are included in process of construction of EI digital twin, the more functional educational web environment becomes, forming digital streams that add opportunities for EI. It is assumed that in conditions of web environment of EI digital twin it is possible to exercise the following tasks:

- to implement management, organizational, educational processes in blended learning;
- to coordinate the logistics of institution activity;
- to configure virtual training modules for educational tasks;
- to carry out remote analysis and diagnostics of processes taking place in each classroom.

4 CONCLUSIONS

Among the main conceptual provisions of DT application in EI we would like to accentuate the following: "digital representation and system support of EI real life cycle – ensuring quality implementation of all educational functions". Accordingly, EI digital twin is created to facilitate the tasks for the following groups involved in educational process:

- manager:
  - to keep in control all complexity of educational process;
  - to provide entire educational environment for data that has been represented in various systems and EERs;
  - to analyze operational data related to implementation of educational process;
  - to outline the opportunities to improve the quality of educational process, etc.;
- teacher:
  - to carry out educational process (including the use of such components as: schedule, assessment system, teaching materials for disciplines, home assignments, electronic communication, e-library, etc.);
  - to implement self-learning and self-improvement, etc.
- pupil / student:
  - to gain access to quality education due to usage of quality access and quality resources.

Although the development of operational digital model of EI digital twin can be considered a rather difficult task for practical implementation, we should not forget about its expected value, which mostly lies in implementation of basic functions:

1. Ensuring support for organizational and managerial decisions.
2. Reproduction of educational process in real time mode for everyone.
3. Ensuring the integrity of educational system.

If educational institution is ready to create its own authentic digital twin which will be an innovative solution and provide comfortable and understandable conditions for educational process functioning, it can proceed to development of digital twin and pre-answer the following questions:

1. Which of the systems, processes, tools, digital resources would be powerful and effective components for inclusion in EI digital twin?

2. What infrastructure platforms and LMS can be used as a basis for building of digital twin?
3. How EI digital twin can reduce EI expenditures on organization of blended learning?

The found answers will facilitate logical approach to formation of purpose, tasks and ways of digital twin formation, and also the choice of comfortable, clear and accessible web toolkit of its construction. The digital twin as a holistic web resource should cover and combine physical and digital spaces of educational institution and enable all participants of educational process to obtain quality results under any conditions that may be dictated by modern society.

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Training Teachers-to-Be to Create Infographics and Its Expert Evaluation

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Abstract: The study purpose is to develop methods for preparing students to create infographics for educational purposes and its expert evaluation. Creating an educational infographic is an interesting, but quite complex activity for a teacher, which requires both the expansion of existing psychological and pedagogical knowledge and skills, and the formation of new ones. The modules "Infographics in educational activities" and "Expert evaluation of e-tools' quality for teaching students" are offered for teachers-to-be. The determination of the weighting factor of each criterion by expert evaluations was organized. Experimental implementation of the developed modules is carried out. On the basis of the criterion rank, the significance of each criterion was calculated. The indicators to determine the level of preliminary expert evaluations of e-tools are proposed. The results are calculated with nonparametric methods of mathematical statistics. The conclusion is the expert evaluation has different activity stages, gradually becoming a common phenomenon.

1 INTRODUCTION

The increasing speed of the modern digital world, saturated with information and communication technologies, the habits of the modern young generation to multitasking, to the perception of a significant amount of information, lead to the need for changes in the learning process. First of all, changes and significant modernization require didactic tools used in the lesson – such tools must correspond to the methods chosen by the teacher, the specific situation in the lesson, the peculiarities of students' perception of information. In modern conditions, didactic tools should be variable, comfortable, flexible, adaptive, – those that can be changed according to existing class needs or new capabilities of technical means.

It should be noted that currently the range of available electronic tools has significantly expanded for the needs of the lesson on the methodical web portals and pages of pedagogical forums the following types of electronic resources are offered (depending on the educational purpose) (Olefirenko, 2015):

- means-sources of educational information: presentation of information about objects of study (electronic textbooks and manuals, presentations), models of objects of reality (figurative – photos, images, illustrations, videos, etc., verbal – audio recordings, sign – schemes, mental maps);
- means of organizing the assimilation of educational material (electronic simulators);
- means of control and diagnostics of educational process (means of automated testing);
- means of research, creation and reproduction of sources of information.

Infographics nowadays are one of the didactic tools widely used in education, which provide a structured and systematic visualization of models of processes and phenomena in static and dynamic form (Ivanova et al., 2020). Currently, infographics are actively used in the presentation of news or analytical data, in marketing, in journalism. Recently, in the

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form of infographics provide both educational information and policy (including quite official).

There are a number of factors that motivate teachers to use infographics in the learning process:

- infographics are modern, and currently the most powerful way of presenting data, which is clear and familiar to students;
- increasing the number of infographics in the entire media product, in advertising materials, textbooks, etc. requires certain skills – read information, compare it, correctly perceive the data, analyze the data and draw conclusions, which determines the feasibility of including tasks to work with infographics in class;
- due to the brevity, conciseness of information, the ability to compare data, the availability of images that are easy to remember, students are quickly involved in the process of its consideration, in working with data;
- the use of infographics contributes to the formation of students' skills of the future – to analyze and critically evaluate information, depending on the information received to make decisions;
- dynamic infographics allow you to quickly compare data and draw conclusions;
- involvement of students in the independent creation of infographics from the school course is one of the effective ways to master the material, as it requires a lot of work to collect data, select the most useful, systematize information, design it in a convenient form;
- acquaintance with the concept of infographics and the formation of skills in the use of various methods of data presentation is provided by the curriculum of the subject "Computer Science" for students of 10-11 grades of secondary schools at the standard level and in specialized classes.

Thus, our research on the training teachers-to-be to create infographics and its evaluation is in line with current issues.

2 RECENT WORK

The problem of training teachers-to-be to create visual teaching aids is revealed in many psychological and pedagogical studies. The research (Bartlett, 1927; Bilousova and Zhyteneva, 2014; Davydov, 1988; Erdniev and Erdniev, 1976; Holub et al., 2020; Kalmykova, 1959; Kravtsov and Pulinets, 2020; Mazorchuk et al., 2020; Midak et al., 2021; Minsky, 2013; Raputo, 2010; Verbitsky and Kalashnikov, 2015) are devoted to the theoretical and methodological bases of visualization of educational material in the educational process. Despite the variety of existing interpretations of the concept of visualization, researchers agree that due to the growth of information flows visualization is a new means of reflecting the objective world in the mind of the subject, which has significant didactic potential (Raputo, 2010). Under the conditions of visualization, visual images reduce the chain of verbal reasoning and contribute to the synthesis of the image of the concept of greater capacity (Biloshapka, 2007). Visualization helps to focus on the essential components of the learning material and to understand the connections between them. On the other hand, the use of visualization brightens and makes more convincing educational material (Safina, 2010), allows you to create the effect of situational expression, an atmosphere of ease, enriches the educational process (Briantseva, 2006). It is important that visualization stimulates students to comprehend, generalize, clarify perceived images, ensures the completeness and integrity of their perception (Bilousova and Zhyteneva, 2014), activates various forms of thinking students visually effective, figurative, associative and others (Polyakova, 2012).

The development of modern visualization tools is a factor in the creation of both innovative teaching methods and new pedagogical technologies. For example, Manko (Manko, 2009) sees visualization as the basis for the formation of a qualitatively new stage of development of the fundamental principle of learning – the principle of clarity.

At the same time, Bilousova and Zhyteneva (Bilousova and Zhyteneva, 2014) emphasize the need for early preparation of teachers for the use of visualization in the educational process.

In general, the use of visualization in teachers-to-be training allows to solve a number of educational and pedagogical tasks, including the activation of educational and cognitive activities, the formation of skills of systematization, analysis, highlighting, coding and recoding of educational information, development of figurative perception and visual thinking, development of visual culture, etc. (Movchan, 2017).

In turn, mastering the basics of infographics development by teachers-to-be, in the opinion of experts, is appropriate not only in terms of acquiring skills in developing modern teaching aids, but also a powerful means of obtaining their own experience of project activities use of information and communication technologies, etc.) (Grushevskaya, 2016).

Institutions of higher pedagogical education have accumulated some experience in teaching the basics of infographics development. For example, workshops on information technology have been developed, the purpose of which includes mastering a wide range of the most common services of creating infographics (Ponomareva, 2015). Teachers-researchers offer separate methods of teaching infographics development in institutions of higher pedagogical education – work of Grushevskaya (Grushevskaya, 2016) presents the experience of teaching future teachers to create infographics as a multi-stage process, including goal setting, collecting and verifying information, systematization of data and concept development, prototyping, implementation.

Noteworthy are the attempts of scientists to implement new methodological approaches (e.g., acmeological) to prepare teachers-to-be for the visualization of educational information (Briantseva and Briantsev, 2019).

Equally important in this perspective is teachers-to-be training to evaluate existing and own means of visualization. According to Choshanov (Choshanov, 2013), the teacher should be able to choose and develop their own assessment methods that meet the goals and content of education, use assessment data to improve teaching, and motivate students to learn. Problems of assessing the quality of e-learning tools are highlighted in (Alkhattabi et al., 2011; Atanasova, 2019; Bilousova and Zhyteneva, 2014; Bykov et al., 2001; Elumalai et al., 2019; Ginns and Ellis, 2009; Hay et al., 2008; Iryanti and Pandiya, 2017; Kazaine, 2017; Khalid and Ziden, 2016; Leontiev et al., 2020; Little, 2003; Lytvynova, 2013; Lundqvist et al., 2006; Male and Pattinson, 2011; Marković and Jovanović, 2012; Marshall, 2012; Pons et al., 2015; Robert et al., 2016; Stasiecka et al., 2005, 2006; Vasconcelos et al., 2020; Wu and Lin, 2012; Yang et al., 2007; Zhaldak et al., 2021). In particular, Lytvynova (Lytvynova, 2013) notes that expert activity is undergoing a stage of formation, gradually becoming commonplace, and the relevance of research in the field of examination of electronic educational resources is associated with the trend of standardization and systematization of electronic educational content. To this end, there is an active discussion of various aspects of the creation and use of electronic content in the scientific circles of the National Academy of Educational Sciences of Ukraine, the boards of the Ministry of Education and Science, educational institutions and identify the need to substantiate the foundations for creating the expertise (Lytvynova, 2013).

Our previous works highlight the education potential of e-tools for teaching young learners, e-tool creation in various instrumental environments ICT use for young learner (Olefirenko et al., 2019)). However, some problems of students' training for creation infografic and it evaluation have not been covered in previous research studies.

Creating quality infographics is a rather time-consuming, multi-stage purposeful activity of a teacher that requires diverse knowledge, skills and abilities. Thus, our research is *aimed* at developing methodological support for teachers-to-be in designing infographics for the educational process, as well as its expert evaluation.

3 MATERIAL AND METHODS

3.1 Explored Materials Used in the Experiment

The choice of examples of infographics and software used in the experimental study was due to the need to acquaint teachers-to-be with current trends in the presentation of information.

3.2 Methods for Investigation

The following research methods were used in a complex to solve the set tasks and achieve the goal:

- theoretical: analysis of psychological, pedagogical works, systematization of views and achievements of scientists, study of normative documents (to identify requirements for e-learning tools, determine the methodological aspects of training teachers-to-be for expert evaluation of e-learning tools);
- experimental: pedagogical experiment – for experimental testing of the research hypothesis; diagnostic – questionnaires, observations, analysis of the results of control tasks (to collect data to determine the level of formation of skills of expert assessment of students); methods of mathematical statistics (for processing the results of empirical research).

4 RESULTS

Creating infographics for the needs of the educational process is an interesting, but quite complex activity for a teacher, it requires both the expansion of existing psychological and pedagogical knowledge and skills, and the formation of new ones. Considering that at designing infographics, the focus should be done on students of a particular age with their inherent characteristics of information perception, thinking, memory, certain life and educational experience, thinking through the content of infographics requires, first of all, such psychological and pedagogical skills: to determine the purpose development, to predict the actions of the student at working with infographics, which will really lead to the desired result, to be able to plan the actions of students so as to support the interest of the student, to avoid uniformity in the tasks. Considerable attention needs to be paid to the selection of information that should be presented in the form of infographics. To achieve that a teacher needs the ability to work with information and communication technologies for the creation and design of text materials, the ability to search and select the necessary materials in collections hosted on the network (skills to create a search query, sort found resources by various parameters, evaluate their reliability), create and prepare the illustrative materials (cutting the desired fragment, increasing or decreasing its scale, correction of color tones of the picture, overlapping one image on another, adding a text comment to the picture, etc.), skills of structuring and accumulation of prepared training materials on electronic media. It should be noted that despite the availability of a large number of illustrative materials, templates, animations, software development stored in online collections, the teacher must know and follow the general and special rules of the site for copying and using materials, preserving the rights of authors to intellectual property.

In addition, the preparation of materials requires knowledge of the teacher on the selection of color and font design, understanding of the impact of colors and their combinations on the physiological and psychological state of the student, the principles of comfortable information on the computer screen, recommendations for font design information for students of different ages.

The success of infographic training is based on the teacher's knowledge (figure 1) of the peculiarities of the student's perception of information from the computer screen; ability to analyze and recognize such situations on the screen that require adjustments in the placement of information, its structuring and design; ability to edit and correct educational materials to ensure their comfortable perception; condense educational information through accurate formulation and visualization; ability to use logical accents competently – special techniques aimed at attracting the attention of a student to a particular object.

To implement infographics, the teacher can use both universal software (for example, a program for creating presentations) and special ones, which are designed to infographic training. Therefore, the teacher needs to be acquainted with various tools in order to choose the one that will be convenient for the implementation of the plan.

Due to the fact that the conditions of a particular lesson are unique, and the teacher is not able to carry out a full-scale experimental testing of infographics, during which errors can be identified and corrected, which is why it is important to carry out its preliminary pedagogical examination. Examination of e-learning tools (including infographics) includes the ability to assess their compliance with a set of psychological, pedagogical, ergonomic and technical requirements.

We have developed a structure of training modules "Infographics in educational activities" and "Expert evaluation of the e-tools' quality for teaching students", which are taught in the discipline "Design of didactic electronic resources" for masters-to-be in "Computer Science" or elective discipline "Visualization technologies in educational practice" for masters-to-be of any specialty.

The purpose, tasks and expected results of students after studying of the specified modules are defined (table 1). The content of modules has been developed, a set of teaching materials – demonstration materials has been prepared, the content of practical and laboratory tasks for students has been developed, tasks for independent elaboration and further discussion have been selected, a set of examples of infographics for analysis and expert evaluation has been selected.

Mastering the proposed modules included the topics presented in table 2.

The pedagogical experiment took place during 2015–2020 years on the basis of the Faculty of Physics and Mathematics of H. S. Skovoroda Kharkiv National Pedagogical University. The study involved 102 full-time and part-time students. The experimental work was carried out in several stages: preparatory, formative, control.

At the preparatory stage, an experimental and control groups were formed. To do this, we conducted a survey on the existing experience of reading the information provided in the form of infographics, on the creation of infographics to present educational material, available knowledge and skills on such activities. According to the results of the survey, we grouped students by the level of identification of their motivation, knowledge and skills in the evaluation of e-tools in four groups: low level, medium, sufficient, high. The obtained results were evaluated by non-parametric methods of mathematical statistics, in particular, by Pearson's criterion: at this stage the difference between students of control and experimental groups is insignificant. Based on the obtained data,

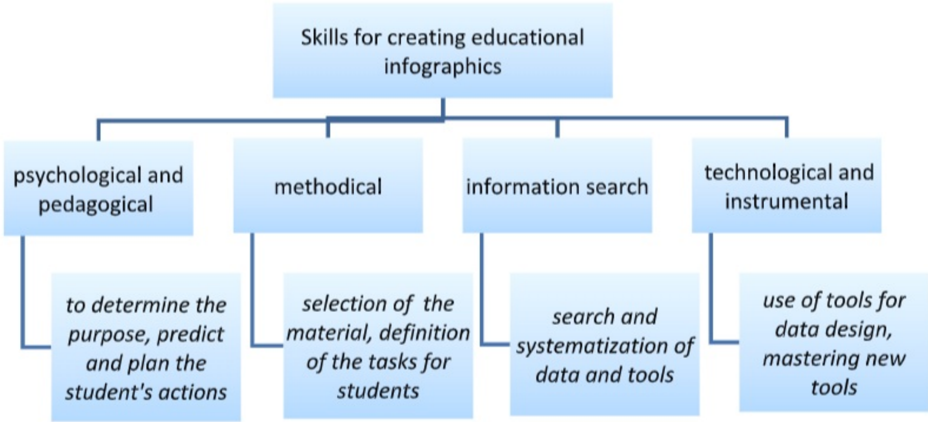

Figure 1: Skills for creating educational infographics.

the contingent of experimental and control groups of students was established – 42 students were included in the control group, 60 in the experimental group, which was due to recruitment to academic groups.

During the formative phase of the study, teachers-to-be learned to present teaching materials in the form of infographics and evaluate them using the method of expert evaluation.

Within the module "Infographics in educational activities" masters-to-be were introduced to the concept of infographics and its importance in presenting information, the historical path of its development. To understand the peculiarities of the use of infographics in the educational process, students compared the ease of perception of information presented in different ways, discussed the amount of material that can be perceived, the importance of design and more. During the practical classes we tried to structure and formalize all the results of the discussion. For example, the content of the infographic and certain features students presented in the form of a table, a diagram or a mental map (figure 2).

Teachers-to-be were acquainted with the types of infographics by the nature of visualization, selected examples of educational infographics for each type.

An essential component in mastering this module was the creation of infographics for the presentation of educational material. Note that since the course is designed for masters-to-be who already have basic skills to use information and communication technologies to design text and graphics, search for tools and install them on a computer, etc., the training was not aimed at mastering the available tools, and on formation of abilities and skills to structure educational information, to create an integral resource, to adhere to one style at registration of text materials, numerical data, illustrative images. Examples of student's works (G. Tsekhmistrova, M. Korotetska) are shown in figure 3.

Teachers-to-be were acquainted with the system of demands for e-learning tools and for educational infographics in particular, learned to determine the degree of compliance in the e-learning tool. To this end, a number of educational infographics were demonstrated, and a discussion was held in which students found out how each of the requirements was met; how different requirements can be implemented simultaneously. During the practical classes it was important that students not only recognize how much a particular demand is met in the proposed tool, but also determine the appropriateness of the chosen methods to ensure it.

Since working with infographics should be comfortable for the student, it is important to deepen the knowledge of the primary school teachers-to-be regarding the general design of the didactic resource and ensure its ergonomics. Students in the process of practical use of various tools on their own experience were convinced that the design and ergonomics of infographics affect the user's desire to work with this resource, to perform practical tasks. In addition, it was important to consider the specifics of the student's perception of information from the computer screen and mobile devices, the impact of certain parameters of the e-tool on the psychological and physical condition of students, principles and norms of comfortable design of didactic e-resource.

In addition, it was important to develop students' ability to make decisions about the design of e-tools depending on its goal and purpose – for this purpose it was proposed to perform a number of tasks in which it was necessary to place and design the provided elements depending on predetermined conditions, to condense textual information (definitions, task texts,

Table 1: Contents of the modules "Infographics in educational activities" and "Expert evaluation of the e-tools' quality for teaching students".

Module	Purpose and objectives	Expected results
Infografics in educational activities	**Purpose**: to acquaint with the technology of creating infographics for the educational process **Tasks**: • highlight the specifics and types of infographics; • to reveal the features of preparation and implementation of infographics for various purposes; • to get acquainted with the tools for creating educational infographics.	**Knowledge**: • essence and types of infographics; • features of choosing the type of infographic for the presentation of educational information; • ways of structuring information. **Skills**: • select and structure information; • use software to prepare materials; • use tool environments to implement infographics.
Expert evaluation of the e-tools' quality for teaching students	**Purpose**: to acquaint with the technology of expert evaluation of e-means. **Tasks**: • highlight the nature and types of testing of e-learning tools; • disclose the procedure for checking e-means; • to acquaint with the principles of professional verification of e-learning tools.	**Knowledge**: • systems of requirements for e-learning tools; • essence and types of examination of e-learning tools; • quality criteria for e-learning tools;

Figure 2: Works of students G. Tsekhmistrova, I. Maistryuk.

Table 2: Topics of training modules.

Topic	Main content
Module "Infographics in educational activities"	
Essence and types of infographics. History of infographic development	Concept of infographics. Types of infographics. Characteristics of types of infographics by the nature of visualization. Research and explanatory infographics. Features of infographics as a means of learning. Historical information on the development of infographics
Infographic design technology	Content of infographic design stages. Selection of educational material for presentation in the form of infographics. Rules for designing headlines in infographics. Requirements for educational infographics. Toolkit for designing infographics for various functional purposes.
Module "Expert evaluation of the e-tools quality for teaching students"	
Psychological and pedagogical demands for e-learning tools	Psychological and pedagogical demands for all types of didactic tools – scientific, accessible, problematic, visual, educational awareness, systematic and consistent learning. Psychological and pedagogical demands that are additionally put forward to e-learning tools – interactivity, multimedia, assistance system. Requirements to be met by electronic means designed to teach students of different ages.
Ergonomic, technical and health demands for the e-resource.	The concept of ergonomics of the learning environment. Ergonomic demands for e-learning tools (for general visual design; color characteristics; spatial arrangement of objects; design of textual, numerical and symbolic information). Ways to ensure health and technical demands in the e-means.
Pedagogical examination of didactic e-resource	Content-scientific, methodical and design-ergonomic examination. Standardization of e-teaching aids. The concept of e-means certification. Criteria and indicators of quality of e-learning tool. Application of the method of expert evaluations when choosing the criteria for evaluating the quality of a didactic e-resource.

explanations, lines of heroes, etc.) which the student should read from the computer screen, competently design it taking into account the psychological and physiological characteristics of the child. Here are some examples of tasks:

1. Analyze the visual design of the proposed infographics on:
   - compliance of the general design of the infographic with its content;
   - emotions that can cause the design of the infographic in the student;
   - the presence of homogeneous or aggressive fields, the feasibility of making changes;
   - the number of objects that are currently in the user's field of view.
2. Formulate the rules of visual design of infographics, taking into account their psychological and physiological features.
3. Design material on the topic "Addressing in spreadsheets", using the provided components. Resize objects, number of slides, color scale, background, etc. Explain the need for changes made.
4. Using a color wheel, select for the specified colors that are contrasting, analogous, making a contrast triad.
5. Get acquainted with the essence of psychological and pedagogical demands that must be met by infographics. Determine how each demand is implemented in the proposed examples.
6. Analyze the infographics. Determine whether different types of fonts are used, which headset and skittle are selected. Determine the distance from which the entire presentation content is clearly visible.

During practical classes at University, students learned to identify the criteria and indicators that were essential for analyzing the quality of the author's e-tools, to analyze the compliance of professional and own developments with the selected criteria. For this purpose, the determination of the weighting factor of each criterion by the method of "expert evaluations" was organized (Orlov, 2001).

For this purpose, students identified a set of criteria for later e-tool evaluation (they minded educational principles; correlation e-tool content with the curriculum; interactivity, multimedia, assistance system; ergonomic demands).

To determine the weighting factor of each criterion, the students in academic group acted as experts and determined individually the rank of each criterion (from 1 to 4). The experimental group received the data presented in table 5.

Figure 3: Student's works of G. Tsekhmistrova, M. Korotetska.

Table 3: Table for task 4.

Name Color	Sample Image	Contrasting Color	Analogous Colors	Making contrast triad
Green				
Red				
Purple				
Light green				

Next, the concordance coefficient was calculated, which indicated the consistency degree of all students' opinion as "experts". In the experimental group the value was W = 0.57, indicating the average degree of consistency in expert evaluations. It should be noted that in the control group, after calculating the concordation coefficient, the table of criterion rank needed coordinating and editing.

On the basis of the table of criterion rank, the significance of each criterion was calculated. For that we found the values that were inverse to the rank sum for each criterion, and then determined the required weighting factors. According to the experts, the importance of each criterion was: correlation e-tool content with the curriculum – 0.35; structured, conciseness – 0.31; adherence to pedagogical principles – 0.19; adherence to ergonomic demands – 0.15.

The students chose one e-tool for self-evaluations. Every student evaluated the criterion degree in the e-tool and expressed it in points from 0 to 3. For example, 3 points for high level, 2 points for sufficient level, 1 point for medium level, 0 point for low level. After that, every student calculated the e-tool evaluation, taking into account weighting factor of each criterion (by the formula $\Phi = V_k \times P_k$, where V_k – weighting factor of each criterion on the basis of expert evaluations, P_k – the demonstration degree of each criterion).

Consequently, as a result of the e-tool expert evaluation, every student gave it a general score: 2.51–3.0 for high level, 1.51–2.50 for sufficient level, 0.76 –1.50 for medium level, and 0.0 – 0.75 for low level.

Table 4: Table for task 6.

Presentation name	**Age / Grade**	**Headset**	**Font**	**Font height, letter height at demonstration through projector**

Table 5: Table of ranks of criteria for e-tool evaluation.

Criterion	**Expert**														
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
correlation e-tool content with the curriculum (x_1)	1	1	1	1	1	2	3	1	1	1	3	1	3	3	1
structured, conciseness (x_2)	2	2	2	2	2	1	1	2	4	2	1	2	1	1	2
adherence to pedagogical principles (x_3)	3	4	3	3	3	3	2	4	2	4	2	4	2	2	3
adherence to ergonomic demands (x_4)	4	3	4	4	4	4	4	3	3	3	4	3	4	4	4

According to the results, students did not always come to the same consensus about the e-tool quality. It indicated different experience levels of using such e-tools, subjectivity in expert evaluation. This indicates a different level of experience in the use of such tools in professional activities, subjectivity in expert evaluation.

At the same time, such activities allowed teachers-to-be to pay more attention to suggestions for improving e-tools, before giving their own evaluation about the e-tool quality.

In the final stage of the experiment, we formulated the indicators to determine the level of formation of skills to create infographics for educational purposes to carry out a preliminary assessment of its quality:

- awareness of the peculiarities of the use of infographics as a didactic tool;
- ability to structure educational material for presentation in the form of infographics and to carry out preliminary training by means of information and communication technologies;
- ability to use tools to create infographics;
- knowledge of the system of demands for e-learning tools (including infographics) for students;
- ability to use the method of expert evaluation to rank certain indicators;
- ability to assess compliance with the system of demands for e-learning tools for students.

The results of the experiment about the effectiveness of teaching students to e-tool expert evaluation based on the indicators presented in table 6. In the table, the control group is marked with letter C, and the experimental one is marked with letter E.

So, the quantitative data show that there have been significant changes in the experimental group as for teaching students for e-tool expert evaluation in comparison with the previous experiment stage: the difference between the control and experimental groups is quite noticeable in almost all indicators. For example, in the control groups the high and sufficient levels as for ability to use tools for creating infographics showed 23.8% and 16.7% of students, in the experimental – 43.3% and 31.7%. A significant difference was also found between the groups in the level of awareness of the peculiarities of the use of infographics as a didactic tool; formation of skills to use the method of expert evaluations to rank certain indicators. The obtained results were evaluated by non-parametric methods of mathematical statistics, in particular, by Pearson's criterion: the obtained values (27.8; 11.0; 12.5; 9.3; 23.8; 22.9) are significantly higher than the critical value, which indicates the effectiveness of the measures to develop students' ability to expertly evaluate e-learning tools.

5 DISCUSSION

No doubt, that a modern teacher should be trained to work in a new digital society, in the face of high expectations regarding teachers' competences relating to the development of e-tools that promote effective schooling. As for expert evaluations by students, any teacher, in our opinion, should be able to choose and develop their own evaluation methods that are consistent with lesson aims and content, to use evaluation data to improve teaching, and to motivate children's learning.

However, it should be noted some difficulties associated with training teachers-to-be to create infographics for the educational process:

- the need for creative abilities of students, the ability to creatively approach the presentation of information, the use of pictorial means, etc. – such skills can not be formed during the training module;
- the need to comprehend a significant amount of information to select the most relevant, structured

Table 6: The results of skills' formation of expert evaluation e-learning tools (percent).

Indicator	Group	Low level	Medium level	Sufficient level	High level
awareness of the peculiarities of using infographics as a didactic tool	C	42.9	28.6	16.7	11.9
	E	5.0	20.0	35.0	40.0
ability to structure educational material and carry out its preliminary preparation	C	26.2	31.0	23.8	19.0
	E	10.0	15.0	45.0	30.0
ability to use tools to create infographics	C	23.8	35.7	23.8	16.7
	E	8.3	16.7	43.3	31.7
knowledge of the system of demands for e-learning tools (including infographics) for students	C	19.0	42.9	26.2	11.9
	E	6.7	26.7	38.3	28.3
ability to use the method of expert evaluation to rank certain indicators	C	42.9	33.3	23.8	0.0
	E	10.0	16.7	33.3	40.0
ability to assess compliance with the system of demands for e-learning tools for students	C	19.0	28.6	42.9	9.5
	E	3.3	6.7	48.3	41.7

presentation as a whole;

- the need to have a sufficiently wide range of software for universal and special purposes for the design of educational information;
- practical lack of localized versions of tools focused on creating infographics, which requires students to have sufficiently developed skills of using information and communication technologies for the preparation of e- materials.

6 CONCLUSIONS

After the development and experimental implementation of the prepared training modules, we came to the conclusion that the development of educational infographics and its expert evaluation is a complex process that requires expanding existing psychological, pedagogical and methodological knowledge and skills, as well as new ones. During the experiment, students learned the features of creating infographics, its types, tools for its creation. The experimental test was successful, as it is confirmed by the methods of mathematical statistics, so we can recommend the proposed methodological support for student learning.

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The Algorithm of Electronic Multilingual Terminological Dictionary Compilation

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Keywords: Dictionary Compilation, Electronic Multilingual Terminological Dictionary, Algorithm, Terminological Unit, Information System.

Abstract: The aim of the present scientific research is to provide a thorough analysis of the algorithm of electronic multilingual terminological dictionary compilation. Electronic multilingual terminological dictionary is viewed as a dynamic electronic lexicographic edition that provides translation, explanatory, encyclopedic parametres of terminological units and is open to current trends in its fields of knowledge representation. Electronic multilingual terminological dictionary covers five knowledge areas, namely Information Technologies, Linguistics, Accounting and Taxation, Engineering, and Economics. It provides English, French, German, Polish and Russian equivalents with encyclopedic reference in all target languages. Moreover, it is absolutely adapted to constant updating, extension and integration with other systems needed. Such dictionary creation presupposes determination of its volume and structure, lexical units' selection and their frequency feedback, and proper arrangement of translation equivalents. Therefore, the algorithm of electronic multilingual terminological dictionary compilation includes seven stages that are dedicated to register creation and arrangement, information system creation and trial, as well as dictionary set-up. All stages are interconnected and interrelated. Accordingly, meticulous stages completion significantly contributes to quality electronic multilingual terminological dictionary compilation.

1 INTRODUCTION

Dictionaries have already become an all-important issue in our modern world. Due to constant technological and scientific progress their importance is inevitable. Dictionaries are universal tools to foster cross-cultural professional communication thus contributing to society advancement. They significantly contribute to thorough objective description of scientific and technical processes. Dictionaries facilitate the users' understanding of lexical units meaning. Therefore, lexicographers are constantly trying to enhance dictionary quality to absolutely satisfy the target users' needs thus making dictionaries a sufficient source of information.

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In the digital era, the computer technologies introduce new interactive ways to overcome time and distance (Toman and Michalik, 2013; Kazhan et al., 2020). Computerization of dictionary compilation makes the search for specific information much easier and more productive. It greatly reduces the timeframes and provides more opportunities to acquire sufficient knowledge on a certain lexical item. Moreover, electronic dictionaries are known for their thesaurus, encyclopedia, learning programs available, data transpost possibilities and other added features. They are user friendly and provide all the necessary information assisting in both private and professional communication. Therefore, electronic dictionaries have already become beneficial for creating a bond among different cultures which is of a great advantage for business communication and scientific advancement.

Furthermore, electronic dictionaries are valued for

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their translation capability and viewed as the main tool of scientific text translation (Tarasenko et al., 2021). They save a lot of time, as the translation of terminological units is done within seconds. Electronic dictionary is mobile and can be easily applied wherever and whenever it is needed. Therefore the development of methods, techniques and algorithms of dictionaries compilation is of primary importance.

1.1 Theoretical Background

Research on dictionary peculiarities, its typology, typology of its users, analysis of needs and skills has a long tradition and is presented in (Hartmann, 1983, 1992, 2009; Hausmann, 1976, 1984, 2007; Kosem et al., 2019; Leffa, 1992a,b; Nesi, 1999, 2000, 2013, 2014; Nimb et al., 2020; Pedersen et al., 2009; Müller-Spitzer et al., 2015, 2018) and many others. The term "dictionary" was first coined in Medieval Latin in the 13th century on the basis of Latin derivative 'diction' (word). Dictionary is viewed as a lexicographic edition arranged in some stated order that deals with the individual words of a language and provides their orthography, pronunciation, grammatical characteristics, derivation and history (Stevenson and Waite, 2011). It is a systematically arranged list of socialized linguistic forms derived from the speech-habits of a certain speech community accompanied by the author's remarks on their usage and aimed at the readers' better understanding. Dictionary has various practical purposes. It is a useful reference book, a 'store house' for a language; a detailed guidebook for distinguishing good usages of lexical items from bad usages, a 'court house' for a language (Dash, 2005). It is the source of linguistic and extralinguistic information which is authentic and reliable.

Burada and Sinu (Burada and Sinu, 2009), Kwary (Kwary, 2011), Weschler and Pitts (Weschler and Pitts, 2000), Winkler (Winkler, 2001) have recognized the advantages electronic lexicographic editions. Electronic dictionary (digital dictionary is a generic term for various types of electronic lexicographic editions and is viewed as any reference material presented in electronic form providing information about the lexical units' spelling, meaning, pronunciation and use (Nesi, 2000). Such a dictionary is a computer database of the specifically coded entries to enable quick word search with regard to morphological form and with the possibility of searching word combinations and changing translation direction (Zavarueva, 2020). It is a new structured text including data represented in different media such as audio files, videos, graph-based views etc. that has a definite volume, a clear aim and serves a specific idea. Therefore, an electronic dictionary is networked, linked to a device, and people-oriented.

Several studies suggest electronic dictionaries characteristic features, namely (Zavarueva, 2020; Müller-Spitzer, 2014):

- a peculiar combination of text and hypertext form of lexical material representation;
- verbal as well as non-verbal means of lexical unit description availability;
- sufficient search facilities within dictionary wordlist as well as in various Internet sources.

There have been numerous studies to investigate electronic dictionaries form and function. Thus, all electronic dictionaries are classified according to (Zavarueva, 2020; de Schryver, 2003; Islam and Purkayastha, 2015):

- a dictionary user (a human or a machine);
- languages involved: monolingual, bilingual and multilingual dictionaries;
- form: online (located in the Internet) and electronic (distributed on CD) dictionaries;
- information arrangement: textual and hypertextual (among which one can distinguish between creolized (with extralinguistic elements such as pictures, audio and video) and non-creolized dictionaries);
- operational system and loading mode parameters: dictionaries designed for MS DOS and dictionaries designed for Windows, non-residential (with their own shell program) and residential (called from other applications);
- word list arrangement: frequency-ordered, alphabetically ordered, thesauruses, thematically grouped, concordances, special purpose dictionaries, combined dictionaries etc.;
- information medium and devices: computer (set up on the desktop computers), pocket (recorder in pocket electronic devices), mobile (used in smartphones), stationary (installed on computer hard disc), portable (distributed on CDs), online (available in the Internet) dictionaries;
- language varieties: normative, literary language, regional dialect, social-group dialect dictionaries and others.

Studies of dictionary structure are well documented (Zavarueva, 2020; Atkins and Rundell, 2008; Jackson, 2003). Prior research proves that electronic dictionary has a well-developed architecture that contributes to quick word search. It consists of macrostructure and microstructure. The macrostructure is viewed as the organization of the lexical entries in the body of a dictionary (Gibbon, 2007) and comes in two types – semasiological and onomasiological. It includes introduction that goes before the body of a dictionary, tables and appendices (supplements) (Čermák, 2010). The microstructure is the organization of lexical information within lexical dictionary entries. It outlines the linguistic unit properties in terms of its content (pragmatics and semantics), structure (syntax and morphology) and rendering (form).

In recent years, research on electronic dictionary compilation has become very popular among linguists (e.g., (Bergenholtz and Bothma, 2011; Rehm et al., 2020; Wright et al., 2013; Wright and Cervetti, 2017)). There exists a considerable body of literature on lexicographical modeling (Kudashev, 2007; Sternyn, 2007), linguistic and machine methods for dictionary compilation (Oettinger et al., 1959), computational approach to lexicography (Atkins and Zampolli, 1994; Čermák and Blatná, 2008), text parsing programs for online dictionaries (Sangeorzan et al., 2008), dictionary writing systems (Rylova, 2010) etc.

Due to constant scientific developments and improvements, significant changes that occur in modern lingual environment are primarily related to terminology. Therefore, terminological units' presentation in electronic dictionaries is in the focus of (Andrianova and Makarova, 2016; Sperberg-McQueen and Burnard, 2004).

The *aim* of our study is to investigate the algorithm of electronic multilingual terminological dictionary (EMTD) compilation. EMTD is viewed as a dynamic electronic dictionary that is open to current trends in its fields of knowledge representation. It is absolutely adapted to constant updating, extension and integration with other systems needed. Moreover, it is rather flexible as for quantitative and qualitative terms. EMTD does not only outline the definition of terms, but also provides English, French, German, Polish and Russian equivalents with encyclopedic reference in the target language. EMTD has a lot of advantages as it aims at providing detailed encyclopedic information which is absolutely necessary for adequate translation. Moreover, it gives illustrative examples that greatly highlight the distinctive features of a terminological unit and shows its usage in different contexts.

2 RESULTS

Electronic dictionary compilation is a meticulous process which takes time and efforts. To compile a quality electronic lexicographic edition all regulations and requirements should be decently followed. In short, the literature pertaining to the peculiarities on dictionary compilation strongly suggests that it is a multifaceted process that includes the following stages (Coward and Grimes, 1995):

- structural, semantic, functional and socio-cultural understanding of language(s);
- structuring and ordering entry information;
- compiling the lexical database;
- checking and refining lexical database information;
- manipulating the data for analytic or other purposes;
- output which presupposes deciding on the format and making the necessary adjustments;
- printing (for printed dictionaries);
- marketing and distribution.

The analysis of existing approaches to electronic dictionaries compilation has driven the further development of the algorithm of EMTD compilation (figure 1).

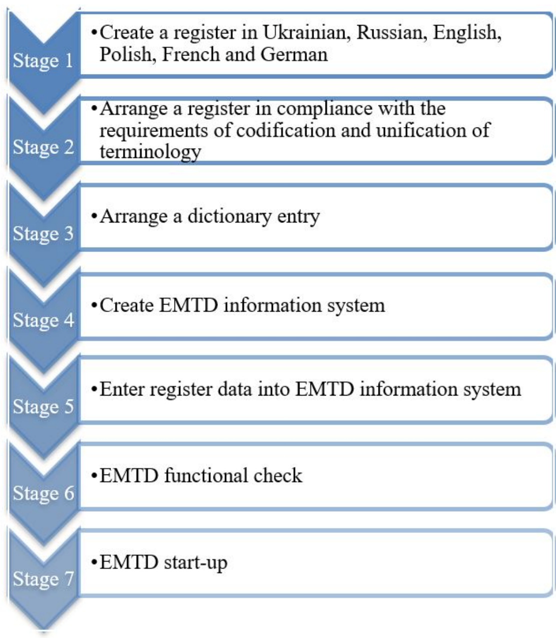

Figure 1: The algorithm of electronic multilingual terminological dictionary compilation.

EMTD compilation undergoes several stages aimed at improving its quality and satisfying the dictionary users' needs. It starts with the creation of the register in the target languages – Ukrainian, Russian, Polish, French and German. As soon as the register is ready, it is sufficiently checked and arranged according to the requirements of terminology codification and unification. The next step is dedicated to EMTD entry structure that presupposes thorough macro and microstructure arrangement. Then EMTD information system is created and register data is entered. After that EMTD should undergo a thorough functional check. Last but not least is EMTD start-up.

Moreover, EMTD creation presupposes comparative and contrastive studies that are based on general principles of terminology analysis. The following principles include comparability, consistency, and sequence of linguistic data analysis (Sternyn, 2007). Comparative analysis is conducted at the level of subsystems, fields and groups, whereas contrastive analysis is done at the level of a definite terminological unit from one language to its possible equivalence in the languages given.

For the current research, it is sufficient to point out the peculiarities of the stages mentioned above.

2.1 Creating a Register

As it has been previously reported, the basis of any dictionary lies in its register. Each word of the register has its own EMTD entry with peculiar structure. A terminological unit is the main structural component of the entry that highlights its grammatical parameters, phonetic and morphological peculiarities as well as synonymic variants if any (Vakaliuk and Chernysh, 2020).

It should be noted that for terminological units' selection we use only authentic texts that meet the following requirements:

- authentic language (written in the author's mother tongue);
- sufficient academic degree of the author (Doctor of Philosophy (PhD), Associate Professor, Professor);
- issue date (less than 10 years).

To create the register the main academic principle of terminological units' selection should be implied. The principle presupposes conducting linguistic and statistical analysis of lexical units from selected sources. The analysis starts with ranking of the terminological units to the frequency of their usage. If a term is widely used the compilers include it in the register.

Each EMTD section is dedicated to a certain area of knowledge and consists of 300 entries. Therefore, a careful and thorough terminological units' minimum selection is a significant prerequisite for efficient EMTD. A well-organized and sufficiently selected register is necessary for the expression of an idea or concept. Therefore, decent register creation greatly depends on mutual efforts and effective cooperation of linguists and specialists in the corresponding subject areas.

2.2 Arranging a Register

Arranging the register special features of terminological units should be considered. Therefore, contrastive and systemic analysis should be implied. Contrastive description of the lexical units' meanings from various semantic categories and different languages has a paramount value. It helps to avoid unwanted terminological confusion and significantly contributes to the users' better understanding of a certain phenomenon. Systemic analysis is done both at the level of comparable subsystems and parallel pairs of terms. It aims at coordination and harmonization of terminological units. Peculiar attention is given to avoid terminological confusion as presence of several terminological units' translations and lack of their thorough distinguishing features as well as erroneous translation equivalents lead to distortion of a term and cause misunderstanding. Thus, terminological system modeling requires the use of comparable logical-conceptual schemes.

2.3 Arranging the Dictionary Entry

Recent theoretical developments have revealed that EMTD compilation should be done in accordance with the following requirements (Verbinenko, 1):

- thorough and sufficient vocabulary coverage of the subject areas;
- availability of the necessary information about the terminological units;
- avoidance of redundant information that increases the dictionary volume, prevents easy word search and consequently causes misunderstanding;
- unification of the dictionary structure and apparatus of links to facilitate the users' search;
- coherence between the dictionary structural components.

Therefore, EMTD entry is of primary importance as it is one of the main EMTD structural components. EMTD entries are viewed as sets of information about terminological units and classified into thematic areas: Information Technologies; Linguistics; Engineering; Accounting and Taxation; and Economics. EMTD entry arrangement should significantly contribute to thorough systematization of terminological unit knowledge on all levels – phonetic, morphological and semantic, therefore it comprises the following parts:

- definition which is one of the most significant constituents of a EMTD entry that provides explanation of terminological units meaning. It serves to resolve the communicative EMTD users needs of decoding and encoding (Atkins and Rundell, 2008). Definition should include only relevant information to meet the expectations of the target users and comply with the general principles (Landau, 2001). It should avoid circularity therefore contributing to better understanding of a terminological unit meaning. Moreover, it should define every word used in a definition not to prevent the user from full understanding. Definition should explain but not just talk about the word and its usage, thus being enough informative
- pronunciation contributes to the correct way of uttering terminological units;
- grammatical information indicates a part of speech, differentiates between transitive and intransitive verbs, countable and uncountable nouns etc.;
- labels are viewed as orientation marks of the region, field or any other specifications according to which the use of a terminological unit can be limited. Labels fall into three types: status, regional and subject. Among them register, style, time and attitude may be as well distinguished (Atkins and Rundell, 2008);
- semantic relations particularly refer to synonyms, antonyms, collocations, cases of hyponymy or hypernymy (de Sousa, 2009).
- phraseology includes phrasal verbs, idioms and collocations which are usually stated at the end of the entry. It may be marked with signs referring to limitations in a word use and followed by relevant examples;
- etymology highlights the origin of a word and its development during the time. It significantly contributes to better understanding of the current meaning and thus enhances the general knowledge of it;
- providing examples is a negotiable issue and depends on the users' expectations. Although, examples should be natural and typical, thus present a term in the most frequent contexts, syntactic patterns, collocations and multiword expressions keeping the balance between too much context and too little (Atkins and Rundell, 2008). Moreover, examples should be informative implying only relevant information not dispersing the users' attention. Last but not least refers to intelligibility which is gained by avoiding sophisticated lexis and structures wherever possible (Atkins and Rundell, 2008).

Most early studies as well as current work focus on the importance of a thorough terminological unit definition. Undoubtedly, a good definition facilitates EMTD users' understanding and greatly contributes to their professional competence development. Accordingly, it should have the following features (Devel and Kovalchuk, 2016):

- have no logical contradictions. The definition should be transparent in meaning. It should not imply difficult terms for rendering the notion;
- be clear and precise;
- have positive predicate;
- be neither overdefined nor underdefined;
- be defined in the simplest possible language.

Furthermore, to meet EMTD users' requirements the compilers make the lexicon easily searchable considering the following features (Burke, 1998):

- headword lookup should be in accordance with printed dictionaries primary macrostructure thus enabling EMTD users to access EMTD entries by simply searching for headwords matching a string they type in;
- part-of-speech indices that help EMTD users to search for entries of a certain subcategory of a part of speech;
- etymology or morphological composition indices;
- register indices that imply reference to literary, slang, professionalisms and other words;
- semantic field indices to provide EMTD users with a hyperlink to a list of all other terms belonging to a particular area of knowledge;
- phonological content of headwords to contribute to EMTD users' correct pronunciation.

EMTD should become a sufficient tool in helping EMTD users to enhance understanding in their readings. Hence, EMTD offers the opportunity of quick six-language A/Z search that makes the search process rather user-friendly and less time-consuming.

2.4 Creating EMTD Information System

Creating EMTD information system requires much time and consideration. The primary concern goes to laying out the database and data flow to the sort of terminological units' visual presentation on the page. Undoubtedly, the era of designing electronic dictionaries in the same way as paper dictionaries has already gone (Heid et al., 2012). Therefore, EMTD should be architected in order to satisfy its users' needs. Every EMTD feature has to be thoroughly planned to make the users' benefit from the dictionary layout.

EMTD has minimal constraints on adding new features or implying more languages. It has two-level expandability, namely: depth (new terminological items may be added to each language); width (new languages may be added). Consequently, EMTD could be further developed and enriched which is significantly important due to constant scientific and technological progress. Thus, we have no technical obstacles to further develop the project on EMTD compilation.

Moreover, EMTD enables smooth data manipulation. It is hosted on university servers that make all the documentation, codebase and language database securely backed up. Furthermore, to satisfy EMTD users' needs, three device types are proposed: computers, tablets and mobile phones. Therefore, the compilers have to ensure optimal accessibility of data on display to EMTD users. Accordingly, responsive design-driven methodology to scale EMTD design down to resolution of 480x960 pixels retaining all the features of the page is implied.

2.5 Entering Register Data Into EMTD Information System

As soon as EMTD information system is created and the register is done in compliance with the requirements of terminology codification and unification, entering register data stage begins. The following stage is rather time-consuming and requires significant efforts. Nonetheless, thorough and meticulous approach used significantly facilitates the process.

2.6 EMTD Functional Feedback

EMTD quality greatly depends on active implementation of EMTD users' needs. Therefore, to corroborate the necessary data several research instruments are used. Open-ended questionnaires, focus group interviews, and email responses are rather helpful in getting EMTD users feedback. A sound idea lies in an urgency to obtain the feedback from the target users while dictionary compilation is still in progress (de Schryver, 2003). Thus, the dictionary-making process is strictly guided in order to satisfy all target users' needs.

What is more, EMTD evaluation is carried out by linguists and specialists in the corresponding areas of knowledge. The specialists take into consideration its suitability and applicability to the curriculum as well as test its features, for instance:

- accuracy;
- multi aspect educational value;
- up-to-date educational standards;
- sufficient language wording;
- complete data;
- ability to encourage and motivate the users' interest;
- ability to improve the users' professional skills.

The following features guarantee the quality of EMTD and its applicability in the educational process. Moreover, EMTD is tested for its reliability, interactivity, controllability, menu, search and control methods, appropriate font, consistent screen layout, technical errors etc.

2.7 EMTD Start-up

Right after EMTD information system is checked, it is given wide public access. It is worth noting that EMTD start-up is not the final stage. This stage presupposes numerous testing of EMTD functions, which is of paramount importance for further EMTD improvement and, accordingly, support.

3 CONCLUSIONS

Constant scientific and technological progress greatly necessitates lexicographical modeling of electronic multilingual terminological dictionaries that hold a central place in the wide range of terminographic editions. EMTD is viewed as a special electronic lexicographic edition that is characterized by translation, explanatory, encyclopedic parameters. It is divided into 5 thematic areas, namely Information Technologies, Linguistics, Accounting and Taxation, Engineering, and Economics. It presents information about terminological units on all levels – phonetic, morphological and semantic. EMTD is valued for quick six-language A/Z search that makes it rather user-friendly. From the research that has been carried out, it is possible to conclude that the process of EMTD compilation undergoes 7 stages including register creation and arrangement as well as EMTD information system creation and functional check. Following the requirements of EMTD compilation algorithm contributes to a quality electronic dictionary creation. Future investigations are necessary to validate the kinds of conclusions that can be drawn from this research. In addition, investigating EMTD model might prove important.

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Features of Utilization Information and Communication Technology in the Process of Teaching the "Environmental Impact Assessment" Course

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Abstract: Increasing demand for experts capable of high-quality assessment of the impact of a particular planned activity on the environment involves a more effective use of information and communication technologies (ICT) in the educational process of training ecology students. The authors present a methodology for students to study the educational material of the "Environmental Impact Assessment" course by using ICT. The methodology and algorithm for using the Padlet interactive whiteboard, Mindomo mind maps, Easel infographics, Google Drive and Google Docs in lectures and practical lessons are described. Particular attention is paid to the preparation of a group and individual projects using ICT. Tested in the Ternopil Volodymyr Hnatiuk National Pedagogical University, the methodology allows to implement a number of tasks such as: promotion of intensification and effectiveness of teaching; acquisition of practical skills to quickly find the necessary information on various online resources for ecology students; simulation of the real procedure of environmental impact assessment in the classroom; development of the ability to professionally communicate with experts in other fields of knowledge or activity, etc. Examination of the results of using ICT to study the "Environmental Impact Assessment" course has shown a significant increase in informational literacy among ecology students and their individual professional growth.

1 INTRODUCTION

Long-term use of biosphere resources by humans has led to a significant transformation of the natural environment. The analysis of degradation processes indicates a violation of regulatory mechanisms that support the stability and durability of ecosystems. Awareness of the problem of natural ecosystems losing their ability of self-recovery has prompted the search for ways to stabilize their state. However, in modern environmental strategies and approaches considerable attention is paid not only to technologies to overcome the already existing effects of anthropogenic impact but also to the development of preventive measures that should avert the negative impact of economic activity on the environment.

Such measures include environmental impact assessment, the purpose of which is to carry out a predictive environmental impact assessment of a particular industrial object or activity at its development stage. According to the expert findings provided in the environmental impact assessment, it is possible to identify environmentally damaging economic projects in advance. Alongside with environmental protection technologies that can reduce anthropogenic pressure, preventive measures ensure the implementation of a sustainable development strategy in the field of ecology. Environmental impact assessment is one of such preventative measures.

Therefore, the compulsory "Environmental Impact Assessment" (EIA) course is included in the curriculum for bachelors of the 101 "Ecology" speciality of Ternopil Volodymyr Hnatiuk National Pedagogical University (TNPU). Studying this subject provides students with the necessary professional skills to qualify as an ecology expert. It should be noted that the learning outcomes provided by the Higher Education Standard of the 101 "Ecology" speciality for the first

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(bachelor) degree of higher education (according to the decree of the Ministry of Education and Science of Ukraine No. 1076 of 04.10.2018), apart from the cumulative knowledge, skills and proficiencies, students must also acquire the following general competencies:

1. Proficiency in using information and communication technologies.
2. Ability to adapt and act in new situations.
3. Ability to communicate with professionals of different spheres and of various levels (with experts in other fields of knowledge/types of economic activity).
4. Ability to work in a team.
5. Proficiency in interpersonal interaction.

An ecology student can become a competitive expert in ecology and be able to respond to the needs of society only when they master professional competencies, which are also specified in the standard, namely:

1. The knowledge of current national and international ecological legislation achievements.
2. The ability to evaluate the impact of technogenesis on the state of the environment and identify ecological risks associated with production activities.
3. The ability to use modern information resources for ecological research.
4. The ability to inform the public about the state of ecological security and the sustainable management of nature.

In general, such a range of competencies as a learning outcome reflects not only the extraordinary dynamism of modern ecology development and its research methods but also the approaches to obtain reliable up-to-date information for a prompt and substantiated response to environmental changes. On the other hand, the content component of the standard for training ecologists stipulates that within the legally set periods of training they must not only accurately master the knowledge base of the profession, but also new methods and technologies of obtaining relevant information to identify trends in the state of ecological objects under the influence of anthropogenic activity.

Environmental impact assessment in Ukraine began to be carried out in December 2017, which is why the "Environmental Impact Assessment" course appeared in the bachelor's degree program in the 101 "Ecology" speciality of TNPU only in 2018. This fact determines the relevance of the development of its educational and methodological base.

Our distinct understanding of these tasks within this course of study has led to the search for methods and learning tools through which the educational process would ensure a great didactic effect. Being concerned about the professional image of our students we perceived this problem as a task that needed an immediate and high-quality solution. In our opinion, one of the ways to solve this problem is to use information and communication technologies while studying the "Environmental Impact Assessment" course.

2 LITERATURE REVIEW

The strategy for sustainable development in the field of ecology involves scientific studies concerning the reduction of anthropogenic impact on the environment. Recently (since 2018), the topic of ecological studies in Ukraine has included the issue of environmental impact assessment. The analysis of the degree of scientific knowledge reveals a lack of study of this issue in contemporary scientific literature.

MacKinnon et al. (MacKinnon et al., 2018) study the history of use of science in environmental impact assessment, as well as provide a conceptual and technical overview of scientific developments related to environmental impact assessment since its inception in the early 1970s.

In Ukraine, since the advent of environmental impact assessment Barna (Barna, 2019) and Naumenko (Naumenko, 2018) have conducted an analysis of environmental impact assessment in comparison with ecological examination.

The issues of using ICT to achieve sustainable development goals have been raised in (Lobanova et al., 2020; Morkun et al., 2017; Williams, 2011). Houghton (Houghton, 2010) explores how the Internet and ICT can help solve environmental problems in developing countries.

ICT has a major impact on education as it opens up opportunities to introduce completely new teaching methods. The investigation of ICT role in the educational process and its impact on improving the educational environment is substantiated in (Bykov and Ovcharuk, 2017; Gurzhiy and Lapinsky, 2013; Morze and Vorotnikova, 2016; Osadchyi, 2014; Semerikov et al., 2020; Spirin, 2011). Fedoniuk et al. (Fedoniuk et al., 2015) provide examples of use of Internet resources in the practical course of the "Natural Reserves Education" subject. The results show that ICT qualitatively influence the improvement of teaching and evaluation methods and contribute to the development of students' information culture (Fauville et al., 2014; Adu and Mireku, 2016).

However, researchers have not outlined ways to use ICT in the process of studying the “Environmental Impact Assessment” course so that ecology students could acquire practical skills. Without this approach it is difficult to provide quality professional training of future experts.

Thus, the research analysis allows us to infer that there is a lack of scientific papers that would depict the features of the use of ICT in the study of the “Environmental Impact Assessment” course, which makes the above issues insufficiently explored.

The article is *aimed* at explaining the features of utilization of information and communication technologies in the process of studying an academic discipline by future ecology experts. The object of study involves an analysis of application of information and communication technologies in different types of lessons in higher education institutions when studying the “Environmental Impact Assessment” course.

The article that we have presented is based on the analysis of our own experience of teaching the “Environmental Impact Assessment” course for several years.

Monitoring of the students’ knowledge quality indicators and the level of professional competencies they formed based on the results of testing our previously developed methods of teaching EIA using ICT tools shows a positive didactic effect. This indicates the expediency of continuing to work on improving the methodology of teaching the course. In our opinion, the expansion of the range of ICT tools will likewise allow to implement the concept of assessment, which will contribute to more effective individual student progress, increase their motivation and redirect their priorities from external assessment to self-assessment. As a result, it will positively affect the level of formation of professional competencies of future ecology experts, which meets the needs of the modern vision of education.

3 RESULTS

At present sustainable development of Ukraine is impossible without EIA. Environmental impact assessment is a procedure in which potential investors, who plan a specific type of activity, interact with state inspectors, who are required to provide an environmental impact assessment report. The participants also include experts who at the request of potential investors must evaluate the impact of the planned activity on the environment and, if necessary, to propose measures to bring the environmental impact of such an activity to the current regulations of the environmental legislation. The EIA procedure calls forth the involvement of the public, which is empowered to approve or reject the planned activity projects based on the consequences for the environment. Thus, EIA involves the work of investors, ecologists, state experts and the public with basic environmental impact assessment documents, the features of preparation of which future ecologists need to know.

EIA in Ukraine has been carried out since December 18, 2017, according to the law of Ukraine on environmental impact assessment. In December 2019, two years passed since EIA was first used, however, the applied aspects of its implementation require methodological development and improvement. There is also a lack of textbooks for professional training of EIA experts. This significantly complicates the teaching process of this course. For these reasons, the search for effective teaching methods of this subject is relevant and substantiated. It should be taken into consideration that while teaching the “Environmental Impact Assessment” course it is necessary to develop the students’ ability to work both as ecology experts and as state experts. Ecology experts need to be able to prepare EIA reports. State experts need to be able to analyze the EIA reports to issue the appropriate conclusion. These two roles are different, but studying the “Environmental Impact Assessment”course stipulates that the educational competencies of both components of the future profession are developed.

We believe that comparative method with the aid of ICT is the most optimal in this situation.

The latter is a necessary component of the EIA educational process for several reasons: changes to laws and subordinate legislations are most promptly reflected on official websites of the relevant ministry, institutions and organizations; the EIA procedure involves the registration of a potential investor in an e-cabinet, online filing of documents in the EIA register, online communication with the public and state institutions. This involves the formation of future ecology experts’ information competence. All of this has been taken into account by us when developing a methodology for using ICT in the process of teaching the “Environmental Impact Assessment” course.

At the initial stage, we examined information and communication technologies, and as a result, found online resources that allow professors to create conditions in the academic setting for the students’ active educational trajectory (figure 1). At the second stage, the most effective online resources for different forms of the educational process (lectures, practical training, group projects) were selected. At the third stage, the developed methodology was tested during the “Environmental Impact Assessment" course.

Generalization, synthesis and integration of the obtained data concerning the effectiveness of the initially tested method showed the expediency to improve it, which we carried out in the fourth stage of our study.

Lectures. The use of ICT for lecture form of educational process compensates for the lack of textbooks and manuals for this course. The use of ICT allows students to create an electronic synopsis using Internet resources and the Padlet interactive whiteboard, which provides the opportunity to discuss a higher number of questions than that of a traditional lecture.

The lessons were held in computer classrooms where each student was able to use ICT. Issues like course objectives and methods of conducting the lessons, ways of evaluating the level of professional and informational competence, and determined methods of preparing projects using ICT were discussed in the first lecture.

Among the wide variety of online services for conducting lectures interactive whiteboards have been selected to create teaching materials that contain certain information in the form of text, pictures, graphs, photos, videos, infographics, namely:

- Padlet;
- Whiteboard;
- Realtime Board;
- WikiWall;
- Dabbleboard;
- Popplet.

The use of these boards not only allows professors to communicate in real-time online but also to record the lesson (Khmil, 2014). Recording the lesson can be done both by the professor and the students. In addition, professors and students can leave text notes and comments on certain elements, upload and edit files, attach text and pdf files, graphic images using special services on the virtual board. Using simple and straightforward tools, professors can clearly visualize information as a diagram. It is important that group work is integrated on a single site.

In the educational process, virtual boards can be created to:

- post information on the studied topic;
- post information or questions to find information;
- brainstorm to gather ideas;
- organize group work to find a collective opinion concerning the problem;
- do projects together.

Such virtual board learning opportunities have allowed them to be used in the "Environmental Impact Assessment" course lectures. The use of the Padlet interactive whiteboard turned out to be the most optimal use of a virtual board. One of the advantages of this service is that Padlet is convenient to use as a document storage system. Materials uploaded to the board will be available at any time, which is especially relevant for students who were absent from the lesson and those in distance learning.

As an example, we demonstrate the methodology of conducting a lecture on the topic: "EIA as a mechanism to ensure ecological safety".

The first post on the board contained information about the subject of the lesson and the task. It was convenient to search for the EIA law from a drop-down menu of the post directly on the board, which allows you to optimize time spent (without opening new browser tabs) (figure 2). The search result leads to an image with a link to the law on environmental impact assessment, as the main document for studying (figure 3).

In the lecture, after reading another article of the law the students were asked questions in the following sequence:

Question 1. What terms and concepts are confusing or unknown?

Question 2. Define the main content of the article of law, for instance, article 1.

Typically, in response to the first question, students could have written: "What is an institutional framework". The most confusing terms were determined by allowing students to mutually evaluate their posts. Using Padlet's search engine, students found definitions of these terms, offered links, established connections to posts with the corresponding caption on the connection line. In this way, the process of learning new material in the short term "materialized" on the Padlet board during group work (figure 4).

It should be noted that at the initial stages of studying the course the students were not active. This is partly due to the inability to use such information and communication technologies. However, within 10–15 minutes students quickly gained proficiency in the means of ICT, became active and showed considerable interest. At this stage, the lesson was conducted in the form of a brainstorming session. This teaching format contributed to the formation of a positive emotional dimension to the lessons, which increased didactic results.

Being able to access a significant portion of articles of the EIA law in Padlet's search engine via hyperlinks was a great advantage. For instance, article

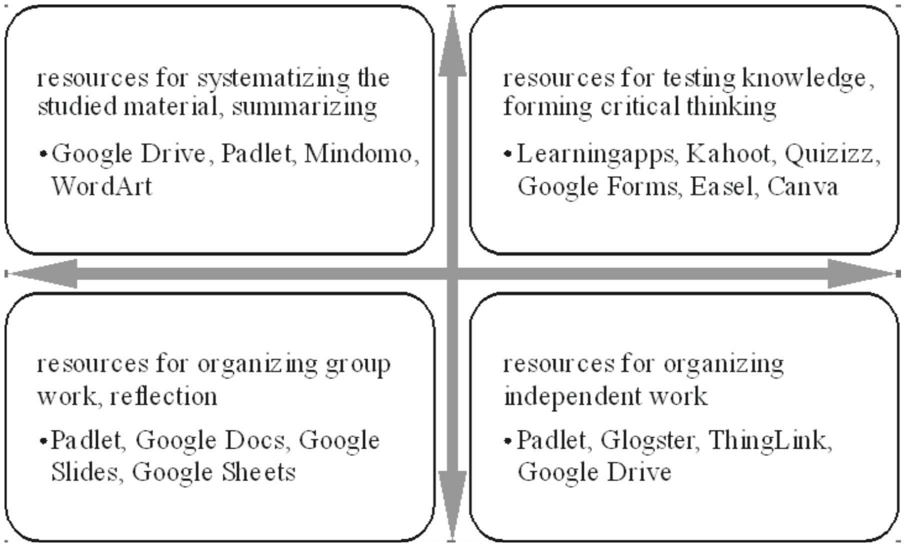


Figure 1: ICT in the academic setting.

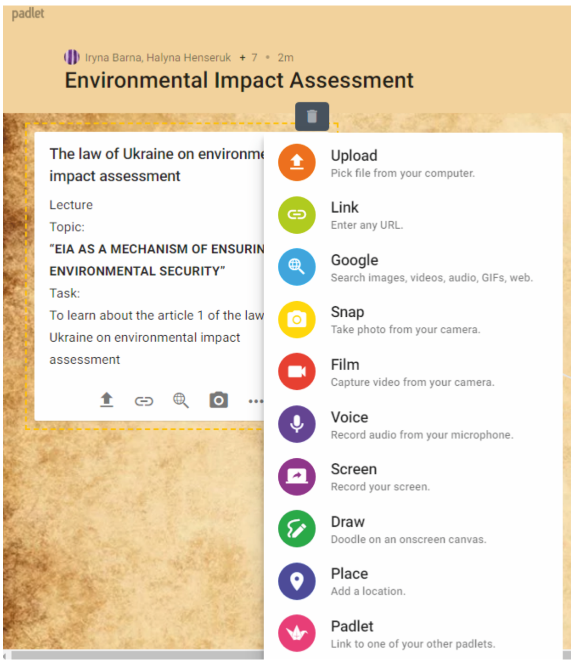


Figure 2: Padlet board content 1 (information search).

1: "Planned activity is planned economic activity that includes construction, reconstruction, ... according to the criteria (originally a hyperlink), approved by the Cabinet of Ministers of Ukraine".

While working with the Padlet board students created a document as a part of an e-synopsis and saved it on a virtual drive. Students took notes (as a separate document) in the form of a table which had 4 columns. While filling in each of the columns the students:

1. Studied an article of the law.
2. Established the main content of the article of the law.
3. Established the significance of the article for an ecology expert.
4. Established the significance of the article for a state expert.

To answer the second question students analyzed the content highlighting the main content (in bold or with a colour) (figure 5).

The format of the table in the text document of the e-synopsis made it easy to organize and summarize the learning material and promoted the qualitative acquisition of knowledge and formation of professional skills. The e-synopsis thus fulfilled the function of a textbook to study the course, prepare for practical lessons and the basis for proper and timely completion of a group project as well as an individual project, which the students were expected to execute in accordance with the organization of the educational process according to our improved teaching methods.

To involve all students in active participation the professor provided them with the chance to analyze all the terms using ICT and to take notes for themselves.

The professor's comments on the students' posts on the Padlet board made it possible for the students to focus on the key information and transfer it to their e-synopsis. In the case of repeated references to the article in the law, the students did not have to reopen the document since the information had already been saved in their e-synopsis (figures 6, 7).

The students analyzed the connections between

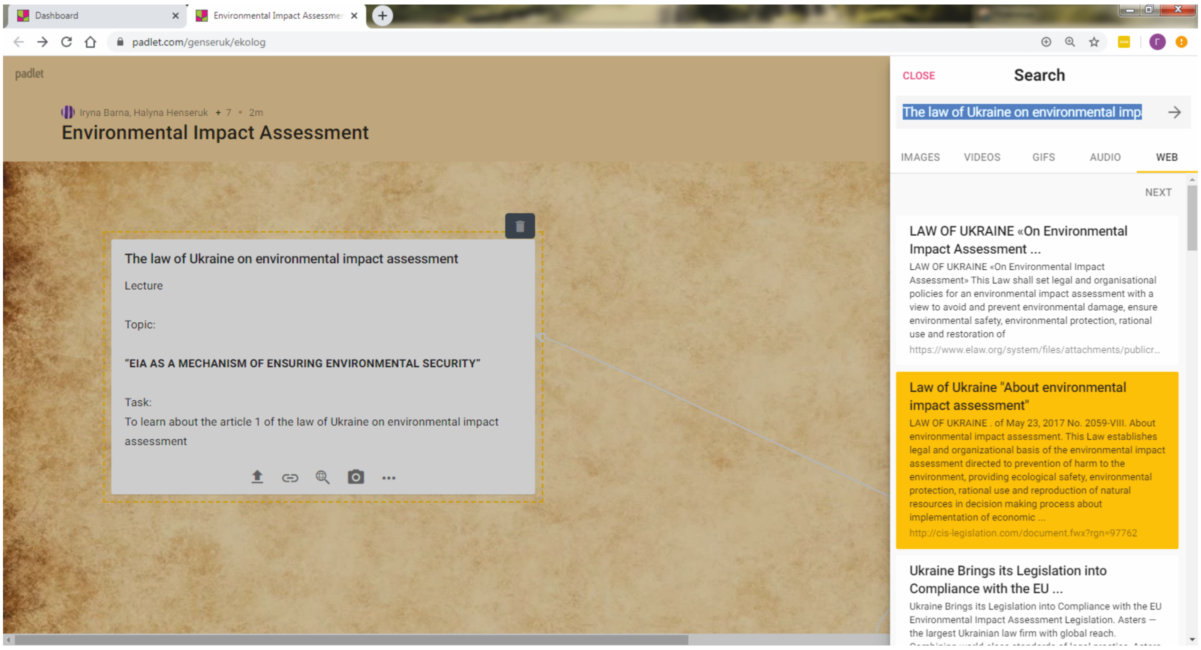


Figure 3: Padlet board content 2 (information search).

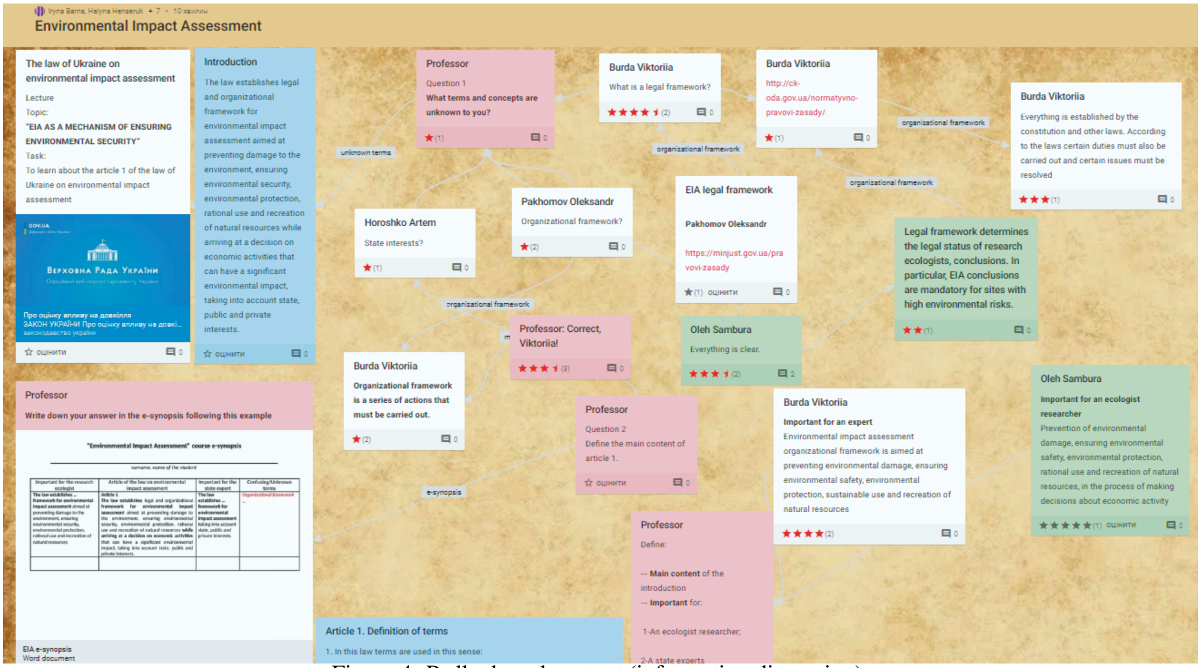
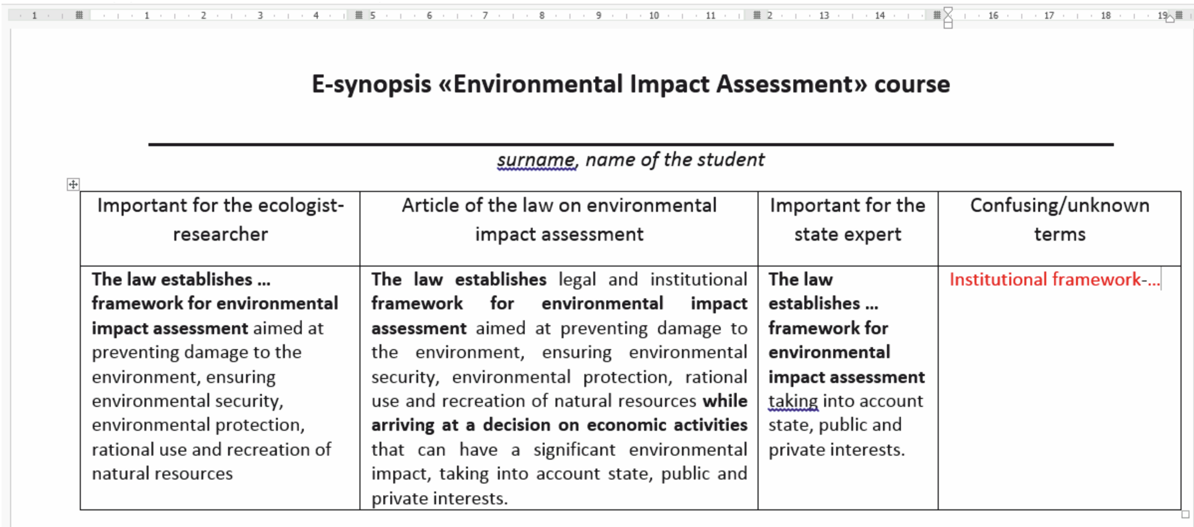


Figure 4: Padlet board content (information discussion).

the articles of the law in an electronic document for a fully understand them and to apply them properly.

Group project. According to the organization of the educational process of the "Environmental impact assessment" course two student groups were expected to prepare an e-project which also used mind maps, in accordance with the initially developed teaching method.

Today the mind map technology is a new tool for structuring and storing information in human memory. One effective way of structuring memorization stages is to provide educational material with a tree structure. Such structures are widely used everywhere where it is necessary to picture a large amount of information in a short and compact way. Mind maps are a convenient and effective technique for visualiz-



E-synopsis «Environmental Impact Assessment» course

surname, name of the student

Important for the ecologist-researcher	Article of the law on environmental impact assessment	Important for the state expert	Confusing/unknown terms
The law establishes ... framework for environmental impact assessment aimed at preventing damage to the environment, ensuring environmental security, environmental protection, rational use and recreation of natural resources	**The law establishes** legal and institutional **framework for environmental impact assessment** aimed at preventing damage to the environment, ensuring environmental security, environmental protection, rational use and recreation of natural resources **while arriving at a decision on economic activities** that can have a significant environmental impact, taking into account state, public and private interests.	**The law establishes ... framework for environmental impact assessment** taking into account state, public and private interests.	Institutional framework-...

Figure 5: Content of the e-synopsis.

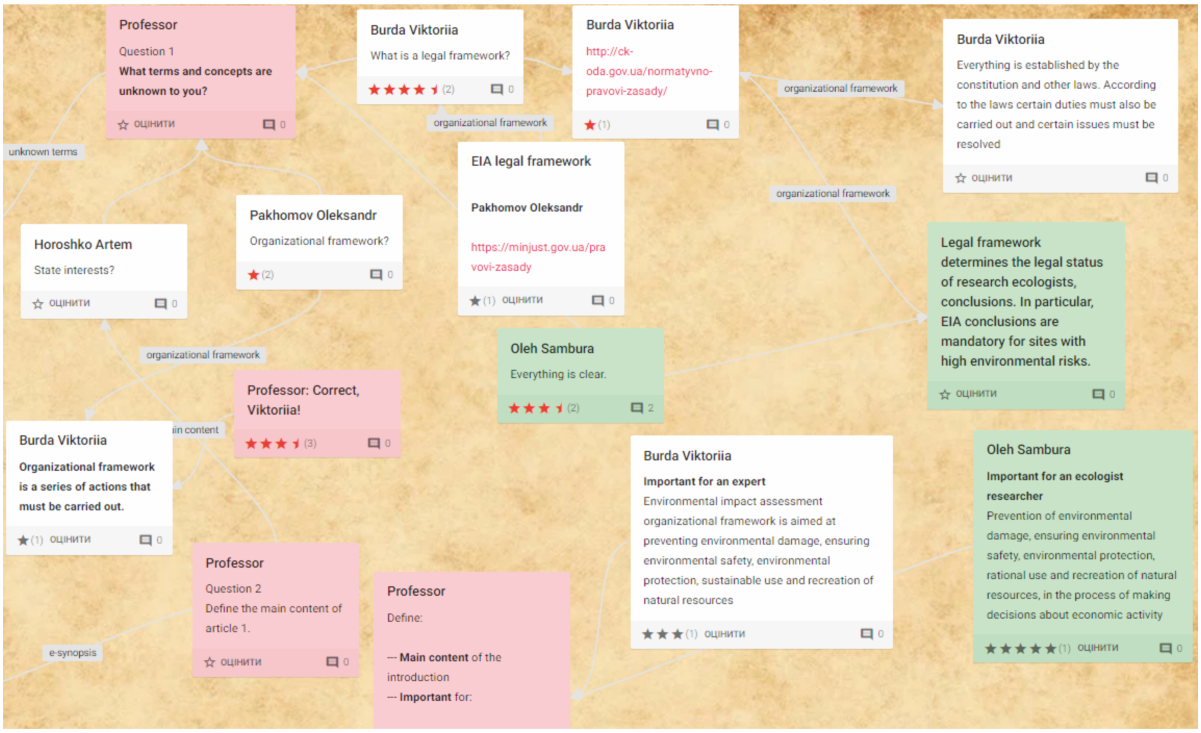


Figure 6: Professor’s comments on the students’ posts.

ing thought and graphic displays of associative connections. They can be used to create and capture new ideas, analyze and systematize information, and make decisions.

There are many online services to create connection diagrams in mind maps (Romanovskyi et al., 2018). The most popular ones are Mindomo, MAPMYself, Mind42, MindMap, Glinkr (Ivanova et al., 2020). To create an EIA project, we suggest using Mindomo. Designing a mind map allowed the students to create a system of related data and identify the stages of activity the sequence of which is consistent with the logic of the EIA process, which in our case will allow us to construct an algorithm of actions of an ecology researcher or an ecology expert (figure 8).

Our study also used the didactic resources of Google Drive, which include tools for creating text

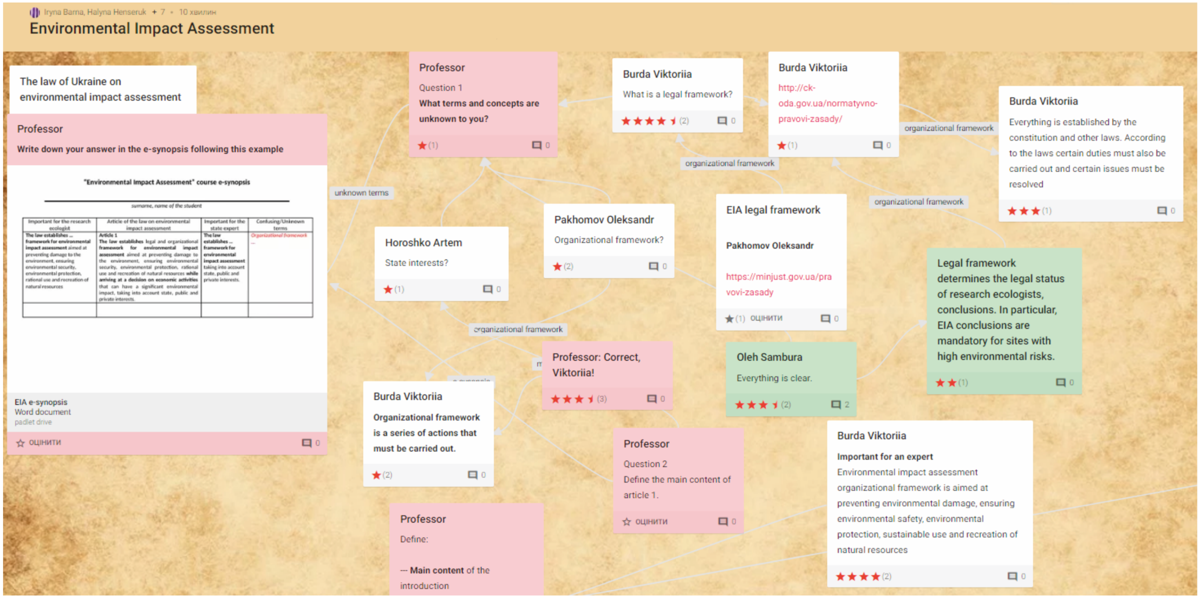


Figure 7: Students' posts assessment.

documents, spreadsheets, presentations, data visualizations. Saving the results of the group project in Google Drive in the suggested by the professor structure was a mandatory and practical work condition, in our opinion (figure 9). The students saved the project on their personal Google Drive and gave access to another group of students.

We find that this method of saving the results has the following advantages:

1) auto-saving of the latest version of the document;
2) variability when checking the work by the professor (the student could choose how to communicate with the professor: through Google Drive or email);
3) the means to check the notes of several students on the example of a single work by the professor online in Google Drive;
4) the ability to mutually analyze the obtained data by multiple users.

One way to present the first folder of the group project was to create an infographic in Easel. It could include a set of pictures of official pages of different state institutions and text blocks from the point of view of their importance for the EIA procedure.

The student groups were tasked to evaluate the project using SWOT analysis technology. The SWOT analysis method involved mutual evaluation of a group project by students according to four criteria. The students evaluated the "strengths" of the project according to the following criteria:

1) the completeness of the answer;
2) the correctness of the answer;
3) adherence to the sequence of stages of the EIA procedure;
4) the manner of representation of items 1-3 in the structure of the presentation.

If the above criteria were partly or fully not met, the students listed them as "weaknesses" of the project. Comparative analysis of the "strengths" and the "weaknesses" of the project at the level of pluses "+" and minuses "–" performed a motivational function, because it identified opportunities or threats.

"Opportunities" during the SWOT analysis of the project were viewed as a sign of full (provided the prevalence of strengths) or partial (provided there were weaknesses) readiness to work as an ecology expert or a state expert. In the evaluation 1 met criterion stood for 1 point or in the case of partial execution – 0.5 points. For example, if a group project fully met the criteria, students rated it at 4 points (figure 10).

"Threats" as one of the categories of the group project SWOT analysis ascertained the fact of the existence of gaps in knowledge, which could potentially lead to the inability to work as an expert in the field of EIA.

The utilization of the group project SWOT analysis allowed students with a low level of acquired knowledge of the course to fill in the gaps during interpersonal interaction with those with a good understanding of the course.

Figure 8: A model of algorithm construction on the example of the EIA procedure.

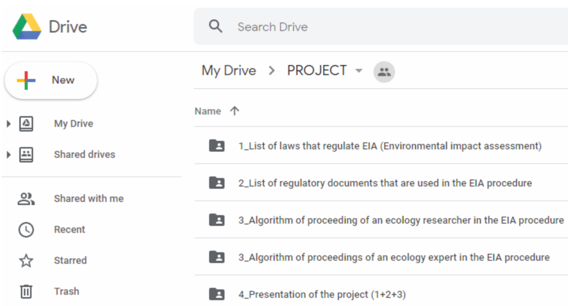


Figure 9: Tasks for the group project.

The method of teaching the "Environmental Impact Assessment" course tested by us proved to be effective, as didactic goals were achieved and professional competencies of students were formed. This ensured a high level of knowledge among the majority of students. Students noted that the lessons possessed a positive emotional nature, which promoted their cognitive functions.

However, this approach to the content and implementation of teaching the "Environmental Impact Assessment" course on the example of the proposed methodology, in our opinion, can be improved, which was achieved as follows.

Lectures and practical classes were carried out according to the previously described method using the resources of the interactive whiteboard Padlet, creating an e-synopsis and saving it on a virtual drive, systematically consulting the professor. However, at the stage of the creating of the project we proposed the following tasks, which were evaluated according to the new approach and with the use of additional ICT resources.

First of all, the nature of the project was changed from a group assignment to an individual one, and its content involved the creation of:

a) presentations;

b) infographics.

During the study of the "Environmental Impact Assessment" course presentation as a method of work and a means of assessment of students' academic achievement should include:

a) all the documents required in accordance with the EIA procedure, prepared according to the examples;

b) the chronological order of presentation of documents according to the EIA procedure.

To determine the quality of the students' knowledge and the formation of their professional competencies and skills, the following evaluation criteria were selected:

1. The semantic component, i.e. the correctness of the filled out documents in accordance with the requirements of the Law of Ukraine on EIA.

2. Adherence to the procedure during the preparation of the documents, which is reflected in the order of the documents in the presentation.

3. The list of used sources, in particular, online pages of relevant organizations.

By their own choice, students formed pairs in which they mutually evaluated their presentations. Students evaluated the presentation of their partner on

Strengths			**Weaknesses**
1. Complete answer	+	–	1. Incomplete answer
2. Correct answer	+	–	2. Incorrect answer
3. Adherence to the sequence of stages of the EIA procedure	+	–/+	3.Full/partial nonadherence to the sequence of stages of the EIA procedure
4.Well-reasoned/well-founded representation of items 1-3 in the presentation	+	–/+	4.Unreasoned/unfounded Representation of items 1-3 in the presentation
Opportunities			**Threats**
Strong – if the strengths exceed the weaknesses by 4 points			***Strong*** – if the weaknesses exceed the strengths by 4 points
Weak – if the strengths are rated at 1-2 points			***Weak*** – if the weaknesses are rated at 1-2 points

Figure 10: The SWOT analysis matrix.

ICT tools for creating infographics and visualizations	• piktochart.com, canva.com, visual.ly, prezi.com, thinglink.com
ICT tools for creating mind maps	• mindomo.com, coogle.it, mindmeister.com, mindmapninja.com, bubble.us, mind24.com
ICT tools for creating virtual whiteboards	• padlet.com, miro.com, whiteboard.com, realtimeboard.com, linoit.com, www.popplet.com
ICT tools for creating surveys,quizzes, interactive exercises	• socrative.com, mentimeter.com, learningapps.org, kahoot.com, quizlet.com, quizizz.com, triventy.com
Google services	• Google Docs, Google Slides, Google Sheets, Google Forms

Figure 11: ICT tools for assessment.

the basis of “correct-incorrect”, which denoted +1 or -1 point.

In order to eliminate any displays of biased evaluation, which would be evident through abnormally high or low marks, the students’ evaluation was overseen by the professor acting as a facilitator, who simultaneously evaluated presentations according to the same criteria.

The discussion of the mistakes in the presentation took place with the assistance of excellent students. After giving their fellow student a chance to correct their mistake they proposed the correct solution. Moreover, the discussion took place from the standpoint of assessment, which allows you to assess and adjust the educational process.

Assessment of tasks executed by students should be diagnostic in nature, as it allows to identify inconsistencies between the program requirements for the students’ education level and to establish gaps in the acquisition of the educational material. Assessment has particular goals, methods and means of implementation.

Earl (Earl, 2012) substantiates assessment as “assessment for learning”, which occurs when professors use observations about students’ progress, and “assessment as learning”, which occurs when students reflect and monitor their progress to form their learning goals.

Assessment for learning is the process of searching for and interpreting data used by students and professors to address issues concerning their level of learning, in which direction they need to move in and how best to do so (Assessment Reform Group, 2002).

Thus, assessment enables students to be aware of and track their own progress and to create their own learning trajectory with the help of a professor or a consultant.

Assessment develops the students' skill of "studying by learning" and provides an opportunity to involve students as consultants and experts in the educational process. It helps them develop effective strategies of learning. Students who take an active part in the discussion during the learning process; assess the quality of their assignments and their peers' assignments according to clearly defined criteria; develop their own digital competence, in particular, one of its components problem solving.

The introduction of assessment in the educational process is becoming more relevant and effective with the use of ICT tools. Assessment technology provides feedback aimed at improving the educational process.

ICT tools for assesment can be used at different stages of the lesson depending on its goals (figure 11).

Based on the results of the discussion of the presentations from the standpoint of assessment, the students determined which tasks they performed successfully, and which ones need to be analyzed, adjusted and re-done.

The process of evaluating the presentations was carried out using the Mentimeter resource, which students utilized to cooperate in the presence of a professor acting as a facilitator.

Our choice of Mentimeter as a feedback tool is due to three main criteria: an intuitive interface; no need for students to register; multifunctionality, i.e. it is possible to use the resource during any stage of the lesson for various tasks.

Mentimeter is a simple and easy-to-learn voting tool that provides instant feedback from your classroom. It is convenient to use to interview students in real time, as it is available on both mobile devices and on the web.

It is an excellent tool for assessment: students can record their points and assign marks for completed tasks based on certain criteria (correctness, completeness, chronological order) (figure 12). The professor can demonstrate such assignments on lectures when checking homework to brush up on the material, during initial monitoring of understanding of the new material, in the middle of the lesson as a means to identify problem areas, at the end of the lesson during introspection.

The next step of the project involved working on creating infographics.

The utilization of illustrative materials in the educational process is an integral part of a modern professor's activity, and the use of infographics, as one of the new means of visualization, improves the learning quality of the studied material.

Smiciklas (Smiciklas, 2012) defines infographics as a type of illustration that combines design and various data, which allows you to concisely and quickly convey information to the target audience.

The purpose of infographics is to improve the process of information perception; explanation of complex material in simple terms using images; transfer data in a creative, compact and interesting way, which has special advantages over the usual textual presentation of information.

During the research, we have identified two approaches to the use of infographics in the educational process: "professor-student" and "student-professor". In the first approach, infographics are created by the professor to solve certain educational aims (attracting students' attention, structuring data, etc.). In the second approach, infographics are created by the students during the learning process.

The creation of infographics was individual in nature. When creating the infographic the students took into account the mistakes that were made during the creation of the presentation, and therefore it helped them to increase their level of knowledge acquisition. Students independently analyzed the information, structured it and presented it graphically (figure 13). This type of work allowed students to study the material better, analyze its important aspects and contributed to the development of their critical thinking. Thus, infographics became a tool for systematization of knowledge based on the discussion of mistakes made during the presentation. If necessary, the professor provided assistance as a facilitator.

The use of these ICT resources allows you to significantly optimize the process of teaching the EIA course. However, it is only possible to evaluate the effectiveness of our developed and tested methodology by determining the level of formation of professional competencies in ecology students.

The analysis of scientific and pedagogical literature showed that among scientists there is no singular approach to determine qualitative and quantitative criteria for evaluation of the level of formation of professional competencies. For example, Pavlyutenkov (Pavlyutenkov, 2008) distinguishes five levels of professional competence: very low, low, medium, high

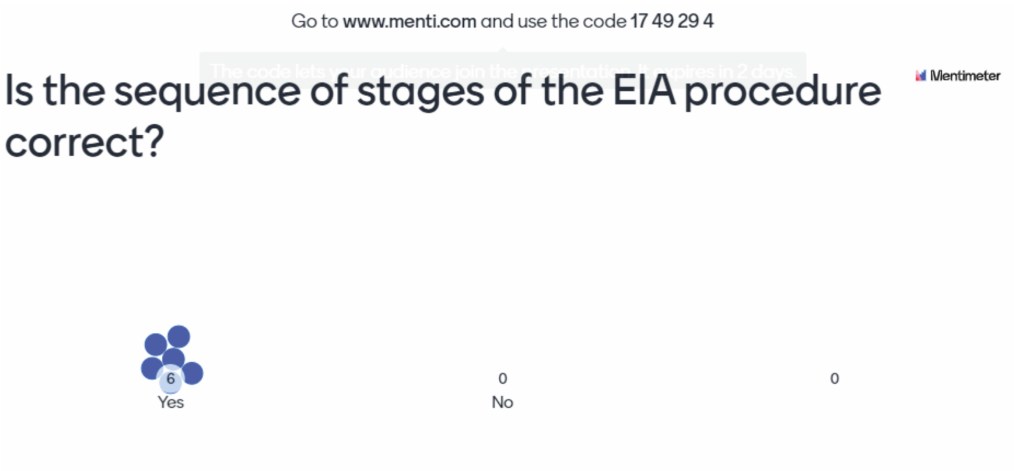


Figure 12: Assessment of completed tasks by students.

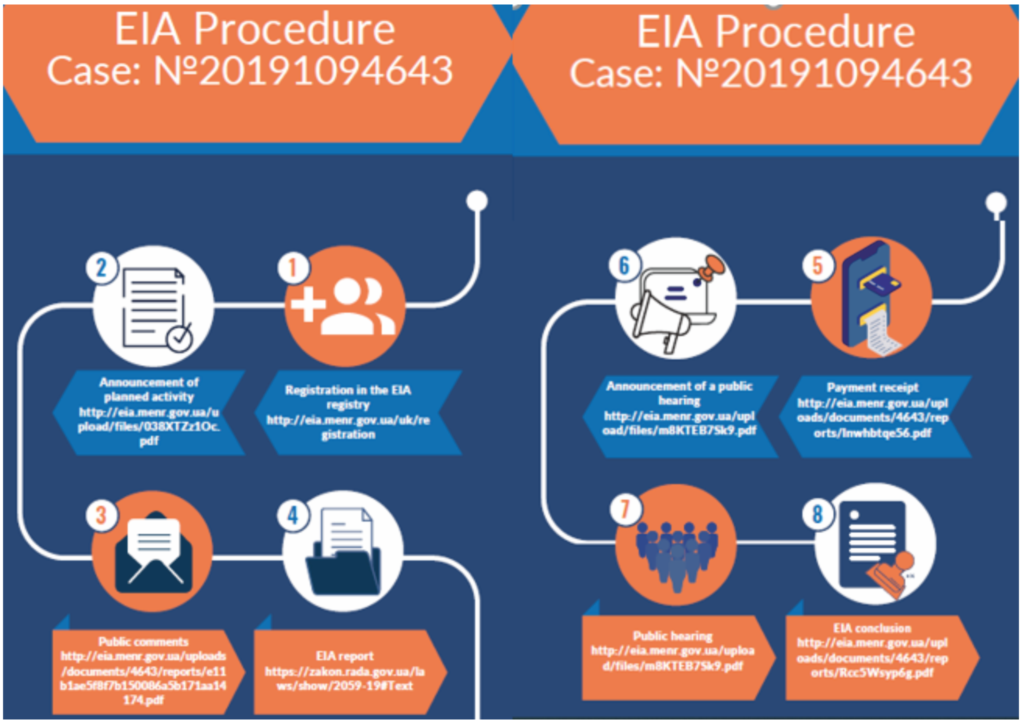


Figure 13: Example of an infographics.

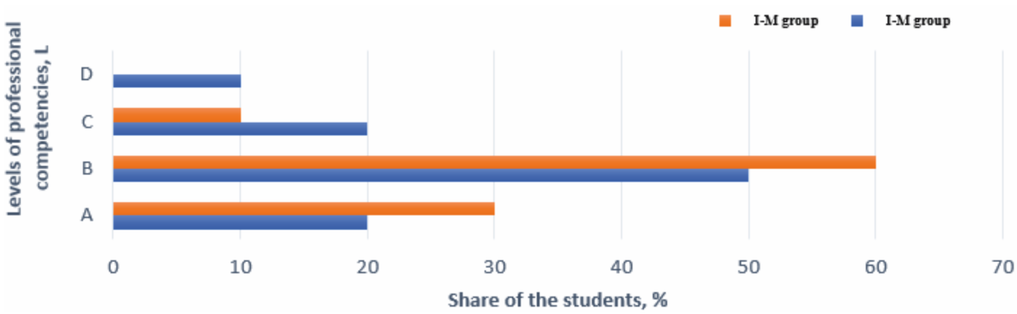


Figure 14: Formation of professional competencies in students based on the methodology of I-M and II-M.

and very high. We proposed four levels (L) of professional competence of a future ecologist: high (LA), medium (LB) and low (LC) and very low (LD). We determined them by the quality of the knowledge acquired by students in the process of studying the "Environmental Impact Assessment" course.

As mentioned above, the methodologies we developed differed in their approaches to the use of ICT resources. The initial (I-M) methodology involved the use of ICT for lectures and group projects (Barna et al., 2020). In the improved (II-M) methodology, ICT resources were also used for individual assignments. We hypothesize that this will affect the levels of formed competencies in students.

To support or refute this working hypothesis we analyzed the level of formed competencies in two groups of students, which differed in the methodology of using ICT in the process of studying EIA. The two groups were: the I-M group and the II-M group. In each of the groups, we determined the share of students with a certain level of formed competence. To achieve this, they were ranked according to the number of points gained: LD – from 0–60 points; LC – from 60–74 points; LB – 75–89 points; LA – from 90–100 points. In each group, the share of students with a certain level of competence can range from 0% to 100%.

The analysis of the obtained research results showed (figure 14) that by using ICT resources only during lectures and group projects of the I-M group there was a share of students with a very low level of formed competencies.

The share of students with a different level of competencies in the I-M group is lower by 10 per cent compared to the II-M group. The obtained results are presumably caused by the fact that the execution of the group project allowed some students to take a smaller part in its realization. The identification of "weaknesses" and strong "threats" in the process of project evaluation based on the method of SWOT analysis was not individual in nature. Therefore, a low mark for the group project was not perceived by the students as a personal failure. The II-M group students were personally responsible for the execution of their individual project. The use of the Mentimeter resource in the process of discussion of the presentations and infographics incentivized each student to fill in their gaps in knowledge and motivated a more creative and effective presentation of their work.

4 CONCLUSIONS AND PROSPECTS FOR FURTHER RESEARCH

The training of future ecologists in the context of the transformation of higher education involves the acquisition of knowledge and the formation of skills. One of the ways to achieve this goal is to use information and communication technologies in the process of studying the course by future ecology experts.

The initial methodology of conducting lessons and preparing a project in the "Environmental Impact Assessment" course, suggested and tested by us, allowed the students to optimize the time spent searching for educational materials, preparing them and making them applicable as much as possible. Each student was given the opportunity to organize their e-synopsis and project simultaneously via using ICT during at lectures and while preparing for practical lessons. In the e-synopsis they constructed an algorithm of actions of an ecologist as a potential researcher or expert in the field of environmental impact assessment, through the use of distinct guidance from the professor, group work during lessons, and independent study.

While studying the "Environmental Impact Assessment" course, students developed skills of using information and communication technologies in lectures and while preparing a group project.

Through the use of the Padlet interactive whiteboard, students gained the ability to adapt and act in new situations when studying the law of Ukraine on environmental impact assessment or discussing its articles.

With the use of ICT during brainstorming at lectures, practical lessons, group assignments, group projects, students were able to practice communicating with experts in other fields of knowledge or activities. By simulating the real-world environmental impact assessment procedure, students developed interpersonal skills that were reinforced by the use of online resources.

The improvement of the initial methodology based on the use of assessment and additional ICT resources during the discussion of an individual project has provided an increase in the share of students with medium and high level of professional competencies.

Learning the material of all modules of the course, the students acquired the skills to evaluate the impact of technogenesis on the environment through the use of ICT at the stage of studying the EIA procedure.

Examining the learning outcomes showed us that the use of ICT provided students with the ability to use information resources in ecological research for sustainable development goals and individual professional growth.

Positive feedback from students proves the efficiency of using ICT while training future ecologists.

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Organisation of Business English for Specific Purposes Course on Moodle

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Keywords: Online Learning, Business English, Moodle Platform, ESP Course, IT Engineering, Law Students.

Abstract: This paper investigates the factors that determine organizing of business English for specific purposes courses on Moodle platform. We have analyzed the Moodle tools that contribute to student's language skills development which are in line with prospective professional activities of the learners. In addition, we have considered the means Moodle provides in terms of their capability to replenish lack of classic instructor-led in-class teaching and switching of the educational process to online mode as a result of COVID-19 pandemic. The objective of the study is to examine English for specific purposes (ESP) Moodle-based courses as a means to advance the level of English language proficiency in distant learning environment; and to analyze the content peculiarities of ESP courses "Business Communication Technology for Law Students" and "Business English" (for Computer Engineering) focusing on nourishing four fundamental language skills (speaking, reading, listening, writing). Some principles of ESP Moodle course tailoring have been highlighted; they are outcome-oriented approach (providing the learning results are applicable in the professional activity, the materials have been added to the course by right), functional language application (the language structures should be presented in career relevant context), layout (focus on speaking and listening activities), learner's centered approach (a student is a key stakeholder) and facilitating role of the educator. One aim of this study is to assess the extent to which the services providing by Moodle, like Interactive Content (H5P), Wiki, Database Activities, Forums, BigBlueButton and others contribute to enhancing four language skills of the learners. The comprehensive analysis has revealed some predicaments the course designer has to cope with, for example lack of background knowledge in the specific domains or significant difference in the level of English language proficiency within one class. Experimental courses are being testing currently in Donetsk Law Institute of Ministry of Internal Affairs of Ukraine and Kryvyi Rih National University. More than 300 students of different legal and IT specialisms are engaged in the approbation. It should be taken into account that the article represents the interim results and the experimental study has development outlook.

1 INTRODUCTION

Educational system faced the challenges of COVID-19 pandemic and a lot of scholars cope with those problems. Scientists around the world have studied the resources which teachers and students have at their disposal and use effectively on a day-to-day basis. Thus, Lytovchenko and Voronina (Lytovchenko and Voronina, 2020) are working to enhance the process of online education and the kinds of solutions they envisage to use remote learning tool MOOC (Massive Open Online Courses) at university in quarantine. The learning-teaching activities are based on the courses on edX or Prometheus platforms. The students are allowed to choose the course, complete the tasks and send screenshot confirmation of their intermediary progress to the teacher. The researchers conclude that MOOC courses "…compensates for their limitations and addresses students' needs more fully" (Lytovchenko and Voronina, 2020). Mishra et al. (Mishra et al., 2020) study has revealed that most commonly used are platforms and resources amplified by the particular university for their students. As they allege, in India it is SWAYAM plat-

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form which is a group of 32 DTH channels telecasting educational programs e-PG Pathshala run by University Grants Commission, and Mizaram University-Learning Management system (100% of teachers and 60% of students use online teaching and learning models on this platform) (Mishra et al., 2020). Oyedotun (Oyedotun, 2020) emphasizes the role of Moodle and other platforms in the context of COVID-19 lockdown. The scholar notices that Moodle was under-utilized before COVID-19 but became intensely utilized and widely used nowadays (Oyedotun, 2020). There is no underplaying the significance of Google Classroom, Zoom, Skype, YouTube, Facebook streaming, WhatsApp, and Telegram so on.

This project is based on previous experimental work which sought to design the special course "English for Mining Mechanical Engineers" and identify the most appropriate tasks and assignments for e-learning, and to assess the efficiency of this course through its contribution to enhance ESP proficiency of mining mechanical engineering students; and to represent the curriculum of ESP course "English for Mining Mechanical Engineers" based on Moodle platform for students of mining mechanical engineering and reveal the results of its approbation (Shalatska et al., 2020). At this stage our research turns to essential pedagogic issues. The objective of a current research is to integrate general theoretical problematic aspects and practical application. Taking into account all this the purpose of the article is to explore ESP e-based courses as an effective method of improving the level of English language proficiency within the framework of Concept of English Language Development at Universities established by the Ministry of Education and Science of Ukraine in the context of distant learning (MES, 2019); and to analyze the content peculiarities of ESP courses "Business Communication Technology for Law Students"(DLI) and "Business English" (for Computer Engineering) (KNU) with an emphasis on their effectiveness to enhance four fundamental language skills (speaking, reading, listening, writing) under distant teaching-learning conditions.

1.1 Analysis of Recent Research and Publications

We have analyzed and consolidated existing experience and practices at the initial stage of the study. Latest studies describe the use of Moodle as a suitable platform to support distance learning courses, assess its functionality and potential (Abdula et al., 2020; Mintii, 2020; Nechypurenko and Semerikov, 2017). Al Nadabi's study focuses on the use of technology in assessment, and contributes some guidelines that can be useful for creating, developing, implementing, and researching large-scale high-stakes tests on Moodle. According to his research, "Moodle activities are used in a blended learning approach either as practice materials or as informal assessment tools for some course components" (Al Nadabi, 2017). Liu (Liu, 2013) investigates the factors influencing ESL college students' acceptance and use of Moodle in their English classes. Al-An (Al-An, 2013) identifies factors behind the usage of a blended learning approach that could have an effect on students' achievement, motivation, collaboration and communication as perceived by students, analyzes obstacles faced by students in using Moodle in blended learning. Rudnitska and Drozdova (Rudnitska and Drozdova, 2018) analyze the problem of first-year students' of economic specialties self-study organization by means of Moodle system in the process of foreign language learning. Yurzhenko (Yurzhenko, 2019) describes and analyses the work of the future maritime specialists in the e-course. Ziyad (Ziyad, 2016) examines tertiary education students' acceptance of and engagement in a Moodle-hosted writing course, measures time spent in activities, number of downloads from the platform and number of online feedback comments. Zainuddin et al. (Zainuddin et al., 2016) analyses the main tools available on the online platform, and concludes that Moodle is mainly used as a repository for materials. Doctoral thesis by del Mar Camacho Martí (del Mar Camacho Martí, 2006) provides an on-line instructional model to train English Language Teachers in the use of ICT, a general vision on the new instructional modalities from blended learning to distance learning, and deals with the difficulties of including ICT into educational management, such as need to catch-up and update their equipment and training programs for their teachers and students.

Hutchinson and Waters (Hutchinson and Waters, 1987) suggest that the teaching of English for Specific Purposes was born as an evolution that responded to the needs and focused on the learners. Instead of learning English for prestige, they learned it for work reasons. Hutchinson and Waters (Hutchinson and Waters, 1987) determine the guiding principle of ESP: "Tell me what you need English for and I will tell you the English that you need". Anwar (Anwar, 2020) notices that "... the success of the ESP learning process does not only depend on the teaching method of the teacher-designed but also the acceptance of student learning methods as well". With regard to ESP teacher's tasks they are similar to any language teacher's the main one is to encourage the student to attend the classes, be active, to make students interested in writing by involving them in real-world and interesting activities, provide them with the opportunity to interact in groups, to share their ideas, and to help each other deal with specific problems (Sojda, 2015).

Business English or English for Business Purposes is a part of teaching English for a Specific Purpose. According to Fitria (Fitria, 2019), "the goal of any Business English Course is to allow its users to effectively communicate with others in a business environment, whether that communication is in correspondence, face to face meetings, or other methods". In this course, students have particular purpose and focus for learning the language as they study English not only to understand everyday speech, but also use the language in a special context for future career opportunities and needs (Fitria, 2019).

Akyel and Yalcin (Akyel and Yalcin, 1991) are engaged in tailoring ESP textbooks for policemen based on learning needs analyses. They have identified the following components of the target needs analyses: 1) specification of the situations in which target learners will need English; 2) division of the situations into communicative activities (understanding complaints, instructing, asking for clarification etc.); 3) division of the communicative activities into communicative functions and micro-skill for ESP situations; 4) determining what language structures and lexical items the learner needs for target situation.

In 2010 Day (Day, 2011) introduced two approaches to ESP course design: English-through and English-for. With English-for approach, we are teaching learners the specific language and skills they need in order to function effectively at work in English. The starting point is the needs analysis. Therefore it focuses on very special functional language. For example, a policeman is not expected to take part in scientific conferences and write research reports during his/her professional activity so it does not need to be in his/her course. English-for provides the language that a learner needs to be efficient at his working place. There's a strong emphasis on functional language presented in context and skills work, especially role-plays, to practise it. English-for courses are challenging enough and time-consuming, teachers have to be not only language-experts but clearly understand the learners' career needs and nuances. With English-through approach, on the other hand, the focus is on developing learners' level of English, and the ESP field simply provides the context. There's a strong emphasis on learning vocabulary and reading articles about the ESP field. English-through courses are easier to create as an educator can follow the approved syllabus and fill it with professional relevant materials. But experience confirms that in teaching practice these two approaches are closely interrelated.

However, notwithstanding the emphasis on specific language use in ESP, it should be noted that some students have a low overall level of English in non-English speaking countries. In these cases, some of the course content must be General English and a course syllabus might include a combination of language points such as a review of the basic grammar alongside such job-specific situations, participating in meetings, discussing different products and etc. Also the different students in one group may have different levels of language proficiency, but they will have similar jobs in future. These two factors should be taken into account by the educator when designing ESP courses and activities.

In most cases, ESP educators are not experts and do not have some background knowledge of the technical, commercial and scientific areas. Nevertheless, in recent years the Internet has become an authentic materials' source for almost any specialism in ESP; textbooks often provide additional materials for both teachers and students such as workbooks, photocopiable activities, grammar booklets, the extra materials include texts, audios, videos, etc. all combine can be easily adapted for student's needs. Understanding their expectations helps teacher to determine the appropriateness of the materials under consideration and chose the best solution and activities. The vital role in efficient learning ESP plays correspondence between what learners wish to get out of the studying and what the textbook has to offer. Despite there being previous research about the subject of teaching English for Specific Purposes, there is a lack of actual change that has been made to the approaches of teaching English for business and career promoting purposes.

In view of all that has been mentioned so far, based on the previous study's results and on the teaching experience of Kryvyi Rih National University (KNU) and Donetsk Law Institute of Ministry of Internal Affairs of Ukraine (DLI) we may suppose that narrowly targeted English for specific purposes (ESP) courses on Moodle platform could be an effective approach to organize distant educating process in the context of the prolonged lockdown.

2 METHODS

During the preparatory phase of the study in the non-quarantine period of 2019–2020 years we cooperated with the teachers of DLI and KNU to observe students' activity at classes of Foreign Language, Philosophy of Law, Professional Psychological Training of Policemen, Conflictology etc. It sought to examine learners' needs and the relevant situations in which English becomes necessary, to assess the level of communicative competencies and English language proficiency of the students of law and IT engineers. We have resorted to technological cards to make it possible to be accurate. Let us not dwell on the intermediate methods, instead, focus on the objectives of the article.

The experimental experience in our previous research helped to identify the benefits of e-learning approach to teaching and self-tuition based on ESP Moodle course. These are (Shalatska et al., 2020):

- *technological flexibility*: the e-platform provides easy-to-use, affordable and diverse teaching toolkit; it allows learners to reach the course content as many times as they need so they get a deeper understanding of the educational material; the special course assignments have contributed to improve English language proficiency in reading, listening, writing and speaking stemming from complex approach: glossary, texts depositary and databases provide access to a vast range of information and allow students to develop skimming and scanning techniques in reading; authentic materials and communication via discussion forums facilitate foreign language fluency; word-processing applications allow students to prepare and edit the writing assignments and then upload them on the e-platform; multimedia and flash-based presentations enables to practice technological skills along with foreign language skills; on the other hand, Moodle supports the lectures to design author's courses to be fully online, to focus on learning outcomes but not on seeking for appropriate textbooks, printing out and replication materials; in addition, content of courses can be updated easily;
- *adaptability to student's individual aptitude and abilities*: each learner has his own pace of understanding and remembering of the language materials and Moodle based course makes available to follow it; students are not limited in number of attempts, there is no time restrictions if only it is not a reading or listening comprehension test; video clips can be slowed and replayed repeatedly according to student's individual needs and enhance their listening skills;
- *preventing from premonition of failure*: individual work combined with ongoing online support to assist the students in his education and to avoid mishaps and criticism from other group mates makes it possible to succeed in achieving the anticipated outcome;
- *impartial assessment*: Moodle grounded course makes available quick feedback on learner's activity and clear-eyed evaluation; offered tools ensure quality of assessment and prevent from cheating; there are self-check, machine check and tutor's assessment at participants' disposal; besides, the course can provide groupmates' feedback exchange; as we have seen from experience, the last way of control motivates students to advance their language skills as they have not only produce own outcome but be an expert;
- *differentiation*: Moodle offers some ability to differentiate tasks and assignments according to learners' needs and pace of studying. Multimedia resources enrich the content and make the learning environment more interesting and appealing to the learners.

Two newly designed ESP Moodle-based courses for prospective IT engineers and police officers on Moodle platform have been developed and piloted in Donetsk Law Institute of Ministry of Internal Affairs of Ukraine and Kryvyi Rih National University. The ESP courses testing was carried out with the primary objective of meeting learner's needs and enhancing of four language skills. Selection and analysis of practical assignments, texts, video and audio podcasts were premised on the conceptual framework proposed by Day (Day, 2011). The author of several ESP textbooks, he has tended to stay around the English for ... side (Day, 2011). At the same time he recognizes that both approaches are finding their rightful place at creating ESP courses, it depends on ad hoc features of a specialism. For example, IT engineers do not need to come in contact with many unfamiliar people so it is difficult to imagine a lot of communicative situations with their participation; hence it appears that the need to learn functional vocabulary and reading authentic professional texts is a starting point for ESP designers. On the other hand, police officers contact lots of people every day, so it is to be taken into consideration in drawing up the special course syllabus.

Accordingly, based on the results of theoretical scientific treatises and practical analyses of our previous research we have designed the special courses "Business Communication Technology for Law Students" and "Business English" (for Computer Engineering).

Let us consider their syllabus in terms of the compatibility with four language domains (speaking, reading, listening and writing). The course "Business English" is an optional discipline in the second year of studying a foreign language in the field of "Computer Engineering" in Kryvyi Rih National University, after studying the one-year basic course "English language". The structure of the course "Business English" includes different components that are used both independently and as successive parts within the course. Each element of the course is aimed at achieving a specific target level of proficiency in professional English. The main goal of the discipline is the formation of students' professional language competencies that will contribute to their efficient functioning in the cultural diversity of educational and professional environments.

ESP syllabus for department of Computer Engineering includes four content modules such as:

1. Work, employees and organizations
2. Production. Marketing. E-commerce
3. Finance. Business etiquette. Personal qualities
4. Culture. Telephone conversations and e-mails. Business skills

The first content module considers Business English topics such as types of jobs and types of work, recruitment and selection, ways to improve job opportunities and elaborate a personal plan for lifelong career success in IT, people and workplaces, problems at work, managers, executives and directors, career advice and stories from information technology experts, organizations. The second content module of the syllabus deals with manufacturing and services, competitors and competition, e-commerce, profitability and unprofitability, success and failure, startup success: how to launch a Technology Company. The third content module deals with personal finance, inflation and unemployment, wrongdoing and corruption, business ethics, projects and project management, leadership and management styles. The fourth content module concerns business across cultures, cross-culture communication, telephoning, business communication, curriculum vitae (CV) and job applications, meetings, effective conversation, oral presentation, agreement and disagreement, e-communication. All content modules are partially based on the units from the book series "Business Vocabulary in Use" and include revision of grammar topics such as tenses, time clauses, modal verbs, infinitive, gerund, conditional sentences, passive, reported speech, etc.

In developing the Business English course we used authentic texts related to employee motivation, effective leadership, competitive advantage, and a series of professional topics. The professional representative topics for an ESP syllabus focus on functional areas – language for recommending, expressing opinions, giving advice, showing agreement, etc. The tasks and activities were selected for the purpose to satisfy the emerging need for enhancing such skills as presentation techniques, negotiating, meeting skills of future specialists. The time allotted to Business English (one class per two weeks) is not enough for teachers to cover the whole content. As a result, some points are left uncovered. To overcome this problem, we suggest using Moodle course and where possible, leave reading and writing tasks (individual and collaborative work) for self-study or homework on this platform. According to quarantine requirements student talking time is organized on Google Meet, which ensures plenty of opportunities for speaking practice and discussion PowerPoint presentations.

Accordingly, based on the results of the observation, students' and tutors' interviews we have designed another special course "Business Communication Technology for Law Students" (https://elearning.dli.donetsk.ua/course/view.php?id=516#section-0). The course is represented on the e-learning site of Donetsk Law Institute on Moodle platform. 258 students of different legal specialisms are engaged in its approbation. It is intended for advanced students specializing in criminal police, preventive activities, pre-trial investigation, law enforcement activity and other related specialisms. The purposes of the course have been established in accordance with the criteria of authenticity, purposiveness of the language, and professional appropriateness of the content. This therefore corresponds fully to English-through and English-for approaches. The program of the course is targeted at the wide range of students of legal specialisms of the 2nd, 3rd and 4th years of studying. It stems from their willingness and readiness to adopt learning material and to understand its applicability in their career context. We have in mind the proper level of professional knowledge and also their level of language proficiency. Besides, the ESP course demands motivation, dedication and responsiveness from the students. The main objective of the special course is to improve students' reading, listening, writing and speaking skills within professional context. The course is structured at different levels of proficiency and our program integrates the skills in the professional area into foreign language proficiency.

Let us detail the learning outcomes according to the language domains. By the end of the course students should:

- reveal subject-specific language from a range of authentic sources;
- communicate about legal topics;
- read and comprehend specific legal texts, course brochures and job advertisements;
- differentiate and exploit various sources of infor-

mation (written, spoken and video);

- be aware of principles of writing study- and work-related letters;

The special course "Business Communication Technology for Law Students" consists of ten topical units (TU), which are summarized here.

Syllabus of special course "Business Communication Technology for Law Students":

TU 1. "Importance of Communications Skills for Police Officer's Career"; by the end of this unit students will be able to: acknowledge the need to apply effective communication in practice of law enforcement activities; understand topical vocabulary and learn to use it in an appropriate context; support topical discussion.

TU 2. "Technique of Oral and Written Professional Communication"; learning outcomes: to get acquainted with communicative techniques, identify the key sentence (topic sentence) in a paragraph, write an appropriate CV.

TU 3. "Conflict Resolution Technics for Dealing with Conflicts"; learning outcomes: to collect and organize information, develop an understanding of authentic topical video and carry out practical activity in accordance with a current legislation.

TU 4. "Technique of Business Discussion with a View to Get Necessary Information"; learning outcomes: to master the information of the topical text, make up a plan using the key-words and phrases, annotate the texts.

TU 5. "Etiquette and Code of Ethics for law officers"; learning outcomes: expound critical thinking abilities and cultivate work ethics, improve listening skills; select and summarize the important information.

TU 6. "Interrogation of Witnesses and Suspects"; learning outcomes: exercise skills of summing up the video information, summarize the information, and make up constructive dialogues.

TU 7. "Collaboration with Civil Society and Preventive communication"; learning outcomes: to be aware of exploiting iron in the modern world, creation and excavation of iron ore deposits, adopt the information from video, draft the report of the survey.

TU 8. "Law officer's positive image formation"; learning outcomes: to analyze the information of the video, speak confidently about the key terms connected with positive image of law officers; plan a presentation on the topical video.

TU 9. "Intercultural Business Communication Technique"; learning outcomes: to understand the elements of culture and intercultural communication that impact business interactions (based on the video), analyze a written text in terms of layout, genre, functional types, to enhance your skills in the dimensions of intercultural competence.

TU 10. "Communication with Mass Media"; learning outcomes: to discuss the political, legal, and economic influence of media industries and the balance between business interests and serving the public, analyze media messages and their impact on society and the individual through a critical lens and recognize the purpose and influence of different media messages on diverse audiences.

Vocabulary plays a crucial role in ESP courses. It is important to prepare the word-list of target vocabulary previously and add to about 25-30% of non-target lexis that is in the text or video. Ready-made vocabulary provides a good basis from which to further refine the text / video and makes it possible to understand clearly (to select) what new words to focus on. The ESP course "Business Communication Technology for Law Students" on Moodle platform provides an opportunity to enrich topical vocabulary of the students drawing up Glossary. All the stakeholders are free to add new items, whether they are target, non-target or emergent vocabulary items (emergent vocabulary occurs unplanned during the lesson or working with the text). Each topic of the course contains Glossary, its core part is prepared beforehand by the tutor and experience has shown that about 40-50% of new words are added by trainees.

The Business English course for Computer Engineers also includes Glossary on the main page which is called "Business English Vocabulary". Student can easily add to and find in this Glossary the most common words and Business phrases, with definitions. In the process of creating an entry, they have to find the definition of a new word on the Internet and give an example of using it in an article or a living conversation. Each entry appears with the author's name and the teacher can rate it. The work on creating a common glossary of the student group supports collaborative work, expands business vocabulary, develops the ability to analyze data, highlight the main thing, sort information, also enhances proficiency in reading and writing. This Glossary combines and links two approaches English-through and English-for since the dictionary can contain not only professionally-oriented vocabulary but also words that are found outside the future work environment.

Designing practical video and reading exercises is fully in line with the English-for approach. The source of vocabulary in the course is the authentic reading and listening texts given from real police experiences and training courses for policemen in Canada. As regards the assignments to test understanding of those videos and texts, their wording comply with English-through approach, for example, watch the video and complete the notes below with the appropriate words; put these terms in the order they appear in the video; match the words to their meanings etc. One of the exercises there is on figure 1.

We are working on listening skills based on authentic professional oriented material. This approach works well with drilling exercises aimed to remember the words, collocations or constructions. At the next stage students need to exploit the collocation in real communication. So it makes sense that each unit of the course concludes with a communicative task. Taking into account opportunities which Moodle provides and specific circumstances of e-learning we have developed the communicative situations on the basis of Forum module (figure 2), which makes it possible to organize asynchronous discussions lasting for limited by the teacher period of time.

It is really convenient for learners because they do not have to write their view at once, there is some time to think about and frame their thoughts. Successful online interaction on Moodle forums allows students to drill not just writing skills but the ability to incorporate content into higher levels of thinking, namely critical thinking. There are a few types of forums, for example standard one – every participant is able to start his/her own discussion or otherwise continue someone else discussion, another type – the tutor can limit the time of debates, the number of replies, can allow to upload the files if it supports the learner's point of view. By and large, experience supports this method. It motivates students to communicate with each other, they do not pay attention if the opponent is the 4th or the 2nd year student, they tolerate any other distinctions and the only thing that makes sense is to find support for their position and find the right words to defend their point of view. The role of a tutor is to come up with the suitable career oriented topic to discuss, to frame the task clearly and facilitate the learners' discussion in the proper context. For example, the topic is: How Soft Skills in Police Can Help Win the Day; the offered communicative situation is: Did you know that some of the skills demanded of police officers from society include critical thinking, conflict resolution, trust-building, adaptability and active listening?; the instruction is: How does communicative approach affect community relations? Write 3–5 sentences. Try to reply to your group mates' ideas (https://elearning.dli.donetsk.ua/mod/forum/view.php?id=20499). English-for approach is appropriate to make up such tasks. It is all needs-based. It focuses on the language and communicative skills that are relevant to the learner's prospective career situations. Different types of forums can compensate a lack of live communication, to a certain extent.

Each discussion topic introduced in the course Business English for Computer Engineers (figure 3) includes a video clip selected by the teacher and several questions for students (http://mlib.knu.edu.ua/course/view.php?id=20507). We use the standard forum for general use with open discussion. The teacher and manager have permission to rate student replies. This activity created according to the English-for approach and promotes effective written communication, drills reading and listening skills.

A wiki is a very popular and fast method for creating content or documents as a group. Teachers can post new assignments for students to submit and has editorial control. Wiki tool is used in Business English course for the following purposes:

- students' collaboration; Wikis provide interclassroom collaboration, cross-classroom collaboration, i.e. students can work collaboratively on projects, creating a class product;
- audience extension; work can be organized in different ways, it can be done individually (everyone has their own wiki which only they can edit) or collaboratively (everyone being able to edit it). A teacher can give a task to one or two students, engage all group in work or even several groups the same specialty;
- facilitation of student work, i.e. they can easily distribute work between group mates. The wiki enables editing of an existing document in a really meaningful way, get feedback and allows integration with the work of others;
- practice and improvement of writing skills; Wikis enhance the process of student writing by allowing them to post as much, and as often as needed. It enables teachers to view drafts contributes to effectively assessing student development in writing;
- reflection and generalization of knowledge; Wikis also provides a space for students to construct and reconstruct knowledge.

The assignments are posted on Moodle using the Wiki tool for course Business English for Computer

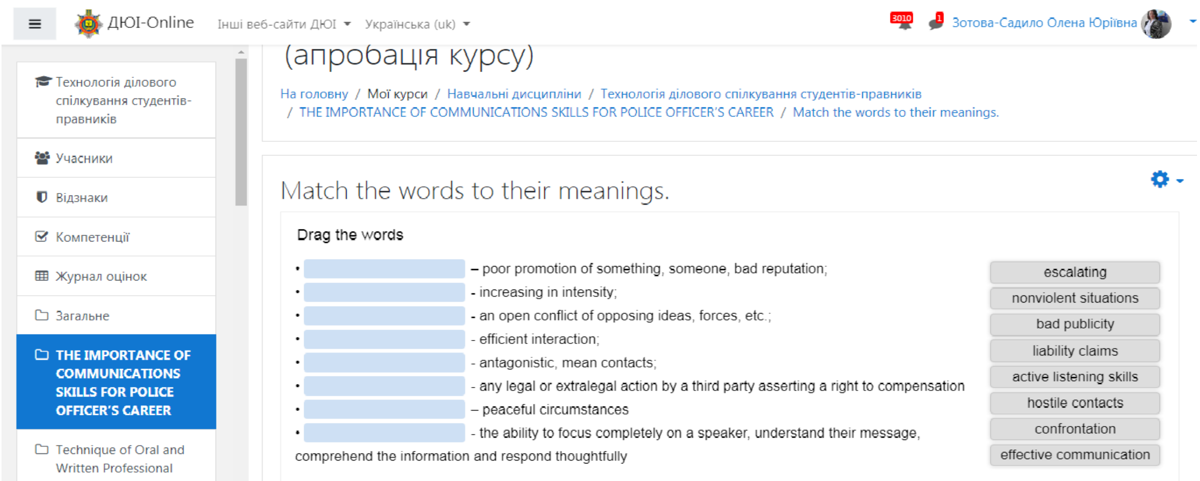


Figure 1: Example of Exercise based on English-through approach.

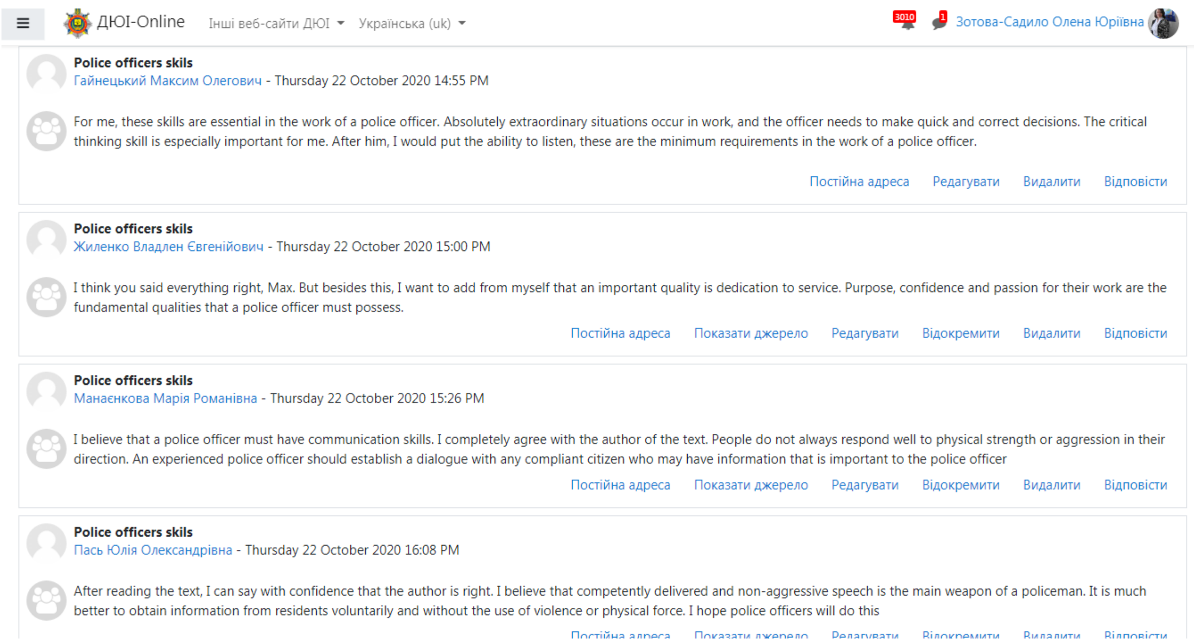


Figure 2: Forum on the theme of "Importance of Communication Skills for Police Officer's career".

Engineers. Students have to find out differences between Resume, CV and Bio-Data, complete the chart (figure 4), list types of resume, and prepare tips for making an effective Resume, CV and Bio-Data (http://mlib.knu.edu.ua/mod/wiki/view.php?id=16201). These papers are the most typical documents to use in the hiring process, possess their own importance and specialty, most of the students are confused with what is the difference between them. This assignment is an example of cross-classroom collaboration, everyone being able to edit this chart, fill empty cells, in this way students from two groups have opportunities to work together.

Wiki Jobs in IT is posted on Moodle within studying the first content module "Work, employees, and organizations". IT professionals help companies maintain their digital infrastructure, provide troubleshooting assistance to technology consumers, keep data security procedures. Students have to provide examples of IT jobs that help them find the right career path that suits their interests, skills, and goals. The assignment involves searching for information on average salaries, typical duties, and requirements for IT professionals. In the process of completing this assignment or any other Wiki, students create multiple drafts while improving their writing, because of the way multiple authors' comment and change texts. In the Wiki, multiple drafts

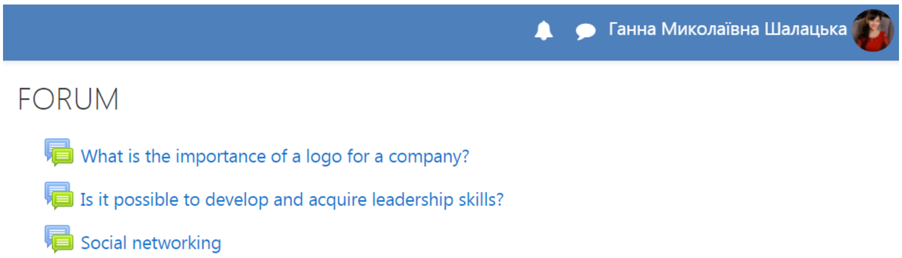
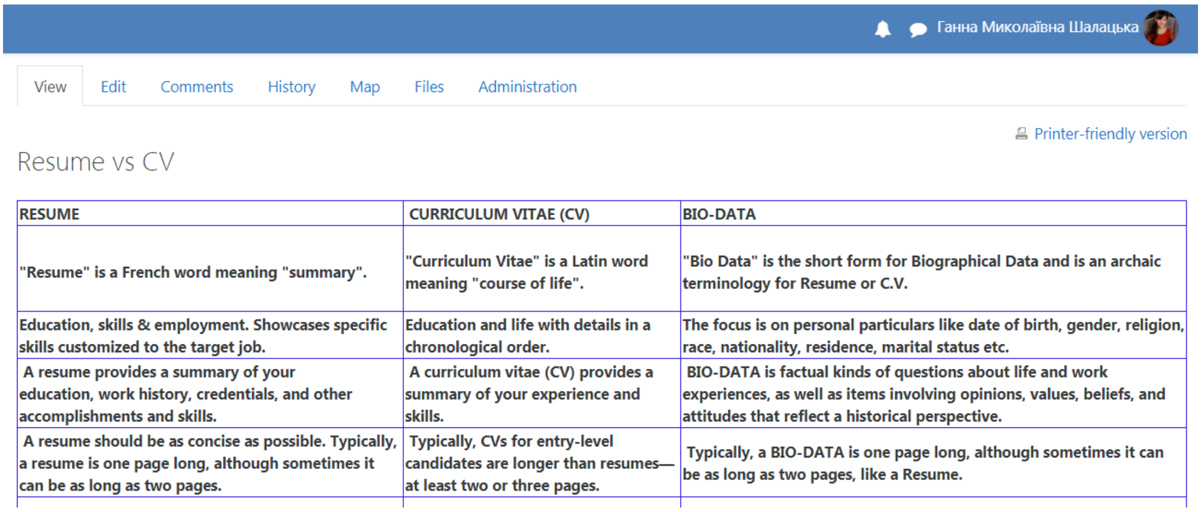


Figure 3: Forums on the course Business English for Computer Engineers.



RESUME	CURRICULUM VITAE (CV)	BIO-DATA
"Resume" is a French word meaning "summary".	"Curriculum Vitae" is a Latin word meaning "course of life".	"Bio Data" is the short form for Biographical Data and is an archaic terminology for Resume or C.V.
Education, skills & employment. Showcases specific skills customized to the target job.	Education and life with details in a chronological order.	The focus is on personal particulars like date of birth, gender, religion, race, nationality, residence, marital status etc.
A resume provides a summary of your education, work history, credentials, and other accomplishments and skills.	A curriculum vitae (CV) provides a summary of your experience and skills.	BIO-DATA is factual kinds of questions about life and work experiences, as well as items involving opinions, values, beliefs, and attitudes that reflect a historical perspective.
A resume should be as concise as possible. Typically, a resume is one page long, although sometimes it can be as long as two pages.	Typically, CVs for entry-level candidates are longer than resumes—at least two or three pages.	Typically, a BIO-DATA is one page long, although sometimes it can be as long as two pages, like a Resume.

Figure 4: Example of Wiki assignment.

can be easily viewed through the revision cycle in the page history (http://mlib.knu.edu.ua/mod/wiki/history.php?pageid=53&page=0). Figure 5 provides a guide to changes the student made, a record of time and date, the process of writing that students undertook, and a history of all versions.

Another Wiki assignment deals with the topic Job Interview (http://mlib.knu.edu.ua/mod/wiki/view.php?id=16205). Students have to know its types, how to handle a job interview, which is an important part of employment, what tips they should have in mind when they apply for a particular job, peculiarities of job interview etiquette, and be ready for the most common questions. This assignment is an example of English-for approach and online inter-classroom collaboration, students edit this online document, distribute work between group mates, make a table of content, then look for the necessary information, place it according to sections, and finally create a class product.

The database activity (figure 6) on Moodle platform allows students to independently build a bank of record entries about topics of the Business English course for Computer Engineers (http://mlib.knu.edu.ua/mod/data/view.php?id=16210). The structure of the entry is defined by the teacher and include text, slide, URL with useful resource, and chart. This activity allows students to search the collection of records within the course, evaluate them and left their comments on entries. Efficient use of this activity in the context of the English-for approach promotes developing student reading and writing skills. Also, these assignments develops critical thinking and initiative, the ability to search and analyze data, facilitate collaboration, and provide access to a piece of new information.

On the other hand, English-through approach is equally efficient. Let us consider the example of that, while policemen are fighting crime and handling emergencies they probably come across many English speakers. Some may commit crimes, while others may be victims of crime. In both cases, police officers need to ask and answer questions in English. Their job may also require them to speak to English speaking witnesses (https://elearning.dli.donetsk.ua/mod/quiz). In the course “Business Communication Technology for Law Students” the trainees are offered to put the words in the right order to get the question or replies necessary to provide some information for English speaking tourists, ask for some identifica-

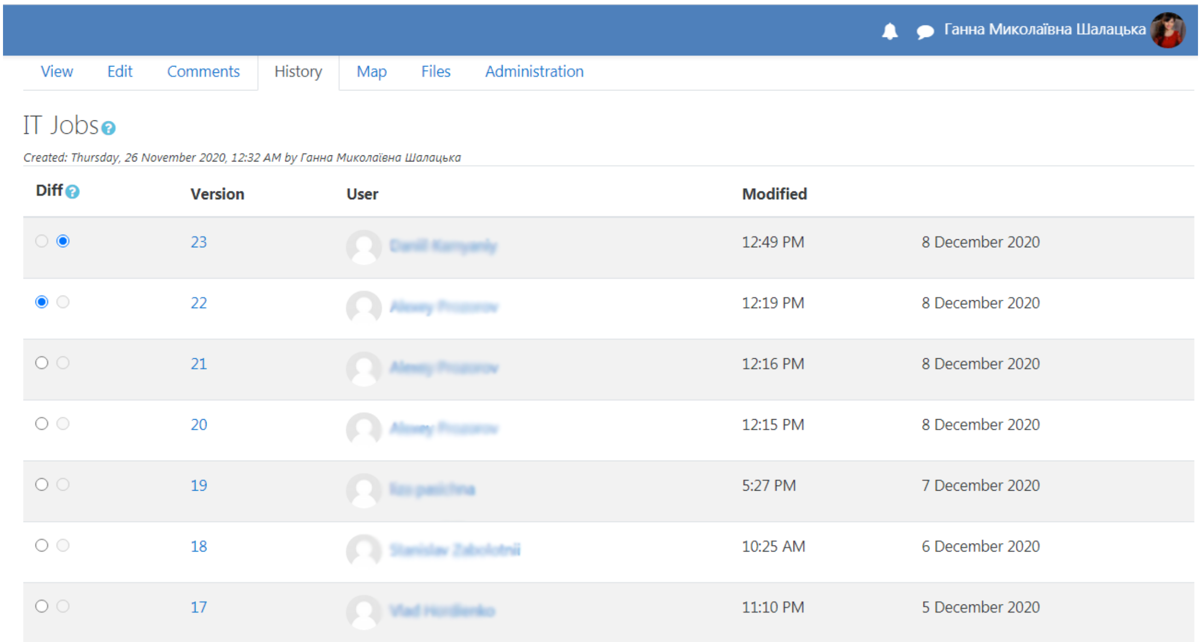


Figure 5: Revisions on the page History.

Figure 6: Database for Business Language Course. The entry "The phone etiquette".

tion or pull people over. This type of tasks includes three exercises from 8 to 10 questions and replies each. While the learners are putting the words in the right order, they are learning important career oriented phrases and collocation. We have used English-through approach to revise the grammar rules but used functional lexis. This proves once again that combining and mixing of English-for and English-through approaches are efficient in teaching ESP courses.

Another tool Moodle provides to teach ESP courses effectively is Interactive content (H5P). It enables the tutor to create interactive videos, question sets, drag and drop questions and many others. In addition to diversifying and makes bright the process of learning, interactive activities emphasize the relevance of professional lexis, videos and texts the teachers have selected for ESP course (figure 7).

We are working on listening skills by giving the students enough challenging things to do; they cannot listen to the text again and again but have to catch the point at once. All of these things could conceivably be done if the learners are prepared and familiar with the lexis. In interactive content activities ESP language are professional oriented. They will apply this knowledge in the future career (https://elearning.dli.donetsk.ua/mod/hvp/view.php?id=33168); everyone will take a job interview. In addition listening exercises are appropriate in both teaching-learning models (online or in-class). If the listening exercises are targeted on the more detailed learning the lexis and text analysis, the students can access to the listening and video material without limitation, they can control the mode of playback – pause, stop, or use rewinds the video. Different forms of learning, remembering and recalling are at teacher's and student's disposal due to applying of Moodle.

In addition, there are other options of online learning run on the Moodle platform. We have worked out assignments, quizzes and exercises for the Moodle course, which are available to the students online, and can be accessed from anywhere. The participants of the experiment have completed the same tasks during blended and traditional classes that have shown the difference between paper and computerized tests. When completing a quiz or assignment on Moodle platform, the students receive immediate feedback on their answers, identify their mistakes, re-attempt quizzes (pass the test once more time) or resubmit the assignment. The special course includes a great variety of activities. The exercises have been categorized according to English-for and English-through approaches and they have positive influence on English language proficiency.

Video conferencing helps compensate for the lack of live communication during a lockdown and we use it as an additional tool to Moodle within complex training Computer Engineers on Business English course. Due to Google Meet educators can see on the screen the whole student group, conduct discussions, and develop speaking skills. When doing distance learning video conferencing helps us to check student's pronunciation and communicate with them more clearly with facial expressions, and intonation. Educators or students can present their screen or a specific window in Google meet, share information such as documents, charts, tables, photos and etc.

Figure 8 provides one of the examples of Google Meet implementation in online teaching Business English course for Computer Engineers. The student shares his screen with the PowerPoint presentation on the topic "The Essential Rules of Phone Etiquette". The process of preparing slides increases the visual impact of information, helps students to focus on a particular topic, analyze and synthesize the material. The question and answer session begins after the student's public presentation of the slides. Such activities are proposed in relation to the English-for approach facilitate to evolve self-confidence, creativity, listening and speaking skills.

BigBlueButton makes it possible to design the links on video online classes in real time in the Moodle course immediately. The web-conferences create an illusion of real presence in the classroom which has a positive impact on the learners' attitude to educational process, they expand bilateral cooperation of students and tutors giving the opportunity to ask for clear explanations and getting feedback. BigBlueButton offers some ad hoc options, for example, the teacher can determine the time range of joining the BigBlueButton conference beforehand and note it into the students' timetable (calendar), note the name and description of a coming lesson. Moodle service sends messages to every student enrolled the course automatically. The learners accede to the web-class easily with no special links or invitations. The only thing they need to do is to enter the course and press the BigBlueButton. One more feature of this Moodle tool is capability to facilitate two or even more conference halls simultaneously.

Taken together, these results suggest that Moodle can be an ideal platform for promoting efficient distant studying and improving language skills because it creates multi-tool learning environment that is convenient to use by teachers and students as well.

3 CONCLUSIONS AND PROSPECTS FOR FURTHER RESEARCH

The present study was designed to examine the scope of ESP e-based courses "Business Communication Technology for Law Students" (DLI) and "Business

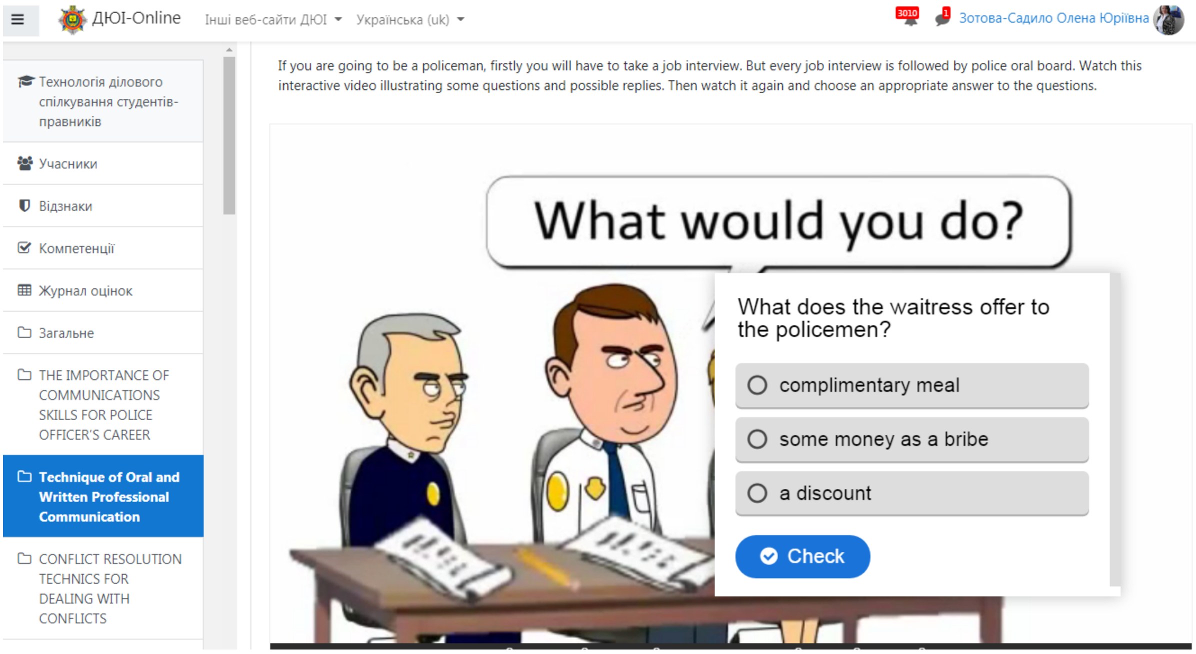


Figure 7: Interactive video; the topic "Police interview questions and answers" (Interactive Content).

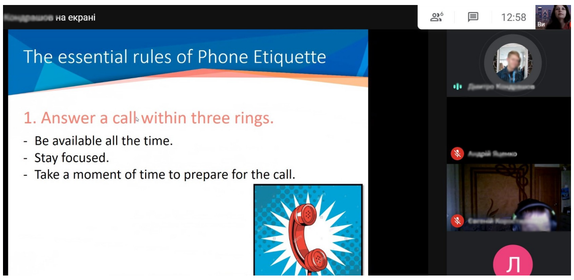


Figure 8: PowerPoint presentation on Google Meet.

English" (KNU), and investigate the options of Moodle platform in order to improve English language proficiency of prospective law enforcement officers and IT engineers. Data from this study reveal that professional oriented special courses on Moodle platform raise the possibility of teaching four language skills (speaking, writing, listening and reading) in online mode during the lockdown period and beyond. The investigation has explored the relationship between four language skills' advancement and apparatus provided by Moodle and some other resources like Google for instance. To this extent, Video conferences based on BigBlueButton (Moodle) and other Internet platforms offer a broad range of opportunities to drill speaking even in distant teaching/learning mode. Interactive content (H5P) encourages the course designer to create interactive videos, questions sets, drag and drop questions and so on. Besides the interactive activities make the educating process bright, they have a substantial influence on listening, reading and writing skills' development. The appropriate use of different kinds of Forums, Wiki and Database activities on Moodle platform in the context of English-for approach brings along enhancing of learner's reading and writing skills. We can conclude that Wiki and Forums services encourage students to share their thoughts and views more freely coping with their fears and uncertainty.

Taken together, these results suggest that the special courses on Moodle platform largely compensate impossibility of face-to-face communication with the teacher or in-class activities. The learners are able to develop and advance their speaking, listening, writing and reading skills according four language domains due to the tools and abilities that Moodle platform provides. This study has set out guidelines to be followed while tailoring the ESP Moodle course. The most significant of these principles are:

- outcome-oriented approach – focusing on meaning and content before form; the materials should be not only authentic but career relevant; if only the outcome is applicable in real professional activity it makes sense; the practicability is important incentive to learn the foreign language;
- functional language – mainstreaming language (lexical sets, collocations, grammar structures) into context using a career relevant situations, new language phenomena are easier to remember;
- layout – an increased focus on speaking and listening skills than writing and reading;

- learner's centered approach – learners are engaged in interaction and informative communication as regards filling of the lesson's content; for example, the students are asked to prepare the presentation or questions to discuss as a home task, they have to select the material, come up with their ideas to demonstrate it and attract the group mates' attention so they try the teacher's role on accordingly;
- facilitating – a prominent reduction of teacher's explanations or his virtual absence changes the role of the teacher from a lecturer to co-facilitator; this, in turn, is linked with the requirement to define recommendations and instructions clearly and meaningful.

The results of our study add to the rapidly expanding field of e-learning on Moodle platform. The empirical findings in this research provide a new understanding of narrowly focused approach to designing of ESP Moodle-based courses and their implementation in the context of distant learning/teaching process under pandemic threatening. The available options and practicalities of Moodle platform have been analysed. Consequently, we have concluded that ESP courses on Moodle platform are able to replenish to some extent the lack of traditional in-class education due to diversity of instruments and activities providing by Moodle and other on-line resources. Moodle can be an ideal platform to promote efficient distant under-facilitation of the teacher or self-studying courses because it creates multi-tool learning environment that is convenient to be used by teachers and students as well.

It is worth noting, the paper presents the intermediate results of the experiment. It is expected to get qualitative and quantitative analysis of students' language proficiency by the end of this year. It is planned to compare the results of the students in 2018–2019 when they regularly attended university classes and in 2020–2021 when educational process was disrupted by lockdowns. This would be a fruitful area for further work.

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Innovative Methods of Information Visualization in Transport Logistics and Training Organization

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Abstract: The paper analyzes the benefits of using interactive teaching methods for students of technical and economic specialties using visualization as an example. In the analysis of existing innovative educational methods, attention is focused on the use of information technology in the formation of competencies of future specialists. In the process of building a software product, a comparative analysis of platforms for developing graphic applications as the main means of visualization on the Internet was carried out. To solve logistic problems that are of practical importance for both economic and technical areas, a visualization of the ant colony optimization algorithm is implemented. It includes building a graph, simulating dynamic network visualization the movement of a large number of ants, saving and loading the graph, providing the user with the ability to remove visible layers. To test the effectiveness of this approach, a multistage experiment was conducted, the results of which allowed us to draw a number of positive findings. In addition, the comparative survey of students from the experimental and control groups made it possible to find out the students' needs in the process of dual learning, which provided an opportunity to increase students' satisfaction with the quality of teaching disciplines.

1 INTRODUCTION

Freight and road haulage by region is part of the transport system of the Ukrainian economy, which every year increases its turnover for the carriage of goods and passengers, as well as overcoming a greater distance of transport. At this time, it is important for enterprises not only to release products and provide transportation services, but also to have their own markets for products. Passengers also prefer to travel by passenger vehicles, which allows them to quickly resolve work issues, sign contracts without being tied to purchased tickets for railway transport. This allows you to quickly resolve business issues, since you do not have to waste time waiting for the departure time of the transport. Road transport provides mobility, which is very important for business. Carrying out cargo transportation, it is necessary to fulfill the conditions of the signed contracts, deliver products to the warehouses of buyers, drive through the branches of the enterprise with an inspection, personally visit the counterparties-consumers of products. For the purpose of marketing products, large enterprises have sales or delivery departments, and small enterprises or entrepreneurs turn to transport enterprises, since they do not have their own fleet of all types of transport. Recently, due to the rise in fuel prices, a topical issue is the construction of an optimal route for the delivery of goods. A very important aspect in delivery is its cost, which depends on building a logistically correct route. This allows you to significantly reduce shipping costs for delivery. At the enterprise, the logistician builds a route in such a way as to fill the car with cargo as much as possible, consistently distribute the cargo to delivery points depending on the chosen direction of movement. The logistician selects the brand of the car corresponding to the requirements and volume of the cargo. The existing car park at the enterprise should not be idle, therefore, if there is a shortage of cars, it is necessary to contact transport companies, and if the cars are underutilized,

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offer delivery services. Before delivering the goods, it is economically feasible for an economist to calculate the cost of delivery of the goods in order to correctly form the price of the service for acceptance.

At enterprises there is a shortage of qualified personnel of the younger generation, therefore, an important issue in teaching students is to consider practical problems, work with computer programs that are found at the enterprise. Now enterprises turn to the university with practical cases to attract students and interest the best of them for further work at the enterprise. For example, Metinvest holds a case championship with students to get a new perspective on their existing problems, as graduate students have new knowledge and skills to work in modern programs.

At the current stage of development of higher education, approaches to accreditation of higher education institutions in Ukraine have been harmonized with those that are used in European practice. Training of Ukrainian National Accreditation experts of educational programs is carried out by the British Council Ukraine company. The "Regulation on the accreditation of educational programs for the preparation of applicants for higher education", which defines the criteria for assessing the quality of each educational program, was approved. According to the criterion "Learning and teaching in the educational program", it is determined that the forms and methods of learning and teaching should contribute to the achievement of the programmed outcomes stated in the educational program. According to the "Standards and guidelines for quality assurance in the European Higher Education Area (ESG)", the quality of higher education should be improved by developing the capacity of teachers at Ukrainian universities to implement a student-centered approach in the projecting and implementation of educational programs. Student-centered learning includes teaching methods that shift the focus of education from the teacher to the student, and among the principles of which are research, discussions and project works.

According to available statistics from the Headhunter International Personnel Portal about staffing with engineers, designers and technologists, there is an acute shortage of qualified specialists at all stages of the industrial product life cycle reproduction. This situation is caused, on the one hand, by the fact that the average age of highly qualified specialists is 40–45 years and above, and on the other, by the gap that has arisen between the requirements of employers for staff competencies and educational standards. Thus, the technological modernization of our country is not feasible without the development and improvement of engineering and economic education, which should be based on the best traditions of the national scientific school with the involvement of modern European developments.

The ongoing changes in the economy and education make new demands on the training of specialists in the field of logistics, adjusting curricula and training courses. In logistics, there is a dynamic transition from a theoretical understanding of the content, as the management of the transportation of goods and people, to an emphasis on the information and technical aspects of practical work. Currently, the study of special computer packages is being introduced into the training program for both economists who plan to work in logistics and programmers who need to be able to complete the technical modules necessary for managers to improve the efficiency of the enterprise.

Analyzing the above-mentioned, it can be claimed that there is an urgent need to form creative thinking among students thus increasing their creative potential. One of the ways to stimulate creativity and self-development is to elaborate innovative methods thereby increasing the motivation of students to master subjects in both engineering and economic specialties, as well as improve the quality of higher education specialists in general. Personnel trained in modern techniques will work in sales and logistics departments at industrial and transport enterprises to improve the efficiency of work and improve the transport system of the Ukrainian economy as a whole.

2 LITERATURE REVIEW

The list of key tasks and a description of the global problem considered in this paper are based on a review and analysis of publications. Speaking of visualization in general, its application for strategic planning by studying the use of interactive visual representations in real time in business strategy process, and the role of visualization in assessing and transferring risks are analyzed in Eppler and Aeschimann; Eppler and Platts (Eppler and Aeschimann, 2009; Eppler and Platts, 2009). Ivanova et al. (Ivanova et al., 2020), Kiv et al. (Kiv et al., 2020), Mazorchuk et al. (Mazorchuk et al., 2020), Osinska and Osinski (Osinska and Osinski, 2018), Soloviev et al. (Soloviev et al., 2020), Vasylenko et al. (Vasylenko et al., 2019) studied the use of information visualization in the social and human sciences, while covering a wide range of topics, including analysis of social networks, complex systems, as well as issues of visualization aesthetics.

The research experience gives a real opportunity to generalize and systematize ideas about teaching methods and technologies. In (Fırat and Laramee, 2018) visualizations of pedagogical research work are analyzed and classified, determining the directions of open research subjects in an interactive visual representation for education, which demonstrate the impact of visualization methods on advanced training. The demonstration of visualization possibilities in computer science and mathematics (Klerkx et al., 2014) emphasizes the effectiveness of its use to improve various types of activities in the educational process.

Emphasizing the fact that modern educational space consists of two types of pedagogical processes – innovative and traditional, Panina (Panina, 2014) identified the differences between traditional and innovative schools at the level of educational technology. Attention is paid to the description and systematization of the most popular and frequently used innovative educational methods of teaching in higher education. According to (Kazhan et al., 2020; Malchenko et al., 2020; Mukhametzhanova et al., 2016; Okopna et al., 2020) the effective use of interactive teaching methods will allow the preparation of qualified, competitive, educated and intellectually developed specialists. In the presented classification of interactive methods, the case-study method is separately highlighted; it allows students to take the initiative in mastering theoretical positions and mastering practical skills.

Focusing on the process of developing educational visualization, Hauswirth (Hauswirth, 2012) promotes the development of pedagogical methods and tools that allow students to learn while creating visualizations on their own. It is well known that socioeconomic changes and information development of the entire world community require the use of information technology in the formation of the competencies of future specialists. By putting more emphasis on the development of algorithmic thinking, the didactic potential for the use of algorithms visualization systems in the process of teaching programming was considered by Moglan (Moglan, 2019). The methods of using the created instrumental environment, that is the algorithms of visualizer within the educational process are proposed. However, it should be noted that the implemented visualizers allow you to interactively demonstrate the operation of the algorithms only for processing static structures. The proposed approach can't be applied for the presentation of more complex data structures. The created visualization system is a catalog of implemented visualizations for a fixed algorithm suite without the possibility of adding a new algorithm to a catalog by a third party user.

Analyzing the techniques of visualization of algorithms in order to create an electronic encyclopedia of graphs algorithms, Gordeev (Gordeev, 2018) considered examples of systems for visualizing them. The advantages of an event-oriented approach and a data-oriented approach and their change are analyzed. The given examples of existing visual techniques for describing the graph algorithm behaviour are considered from the standpoint of having the ability to specify parameter graphs by the user, the ability to specify parameter algorithms, and the ability to adjust the visual part of the image. A comparative description of existing software products for graph analysis is presented in detail in (Kolomeychenko and Chepovskiy, 2014). The authors presented a software package for the analysis and visualization of large graphs. The cross-platform nature of the used implementation tools and the ability of the developed software complex to function in various operating systems allows it to be used in the tasks of sociological and marketing analysis.

The popularity of effective "swarm intelligence" methods explains the constant appearance of a modification of the ant colony method to solve various applied problems. Panteleyev and Alyoshina (Panteleyev and Alyoshina, 2008) proposed an algorithm for solving the shortest path search problem on an oriented graph using the ant colony method. The corresponding software is presented, the performance of which is demonstrated by a specific example. However, the authors have not sufficiently studied the question of the convergence of the method, in particular, the speed of its convergence.

The analysis of these works allows us to conclude that for most visualization systems the introduction of a new algorithm requires the development of the whole visualization system from scratch. In light of the fact that the use of automated systems in the transport logistics branch is one of the ways to save resources, even with a large number of ant algorithms already implemented, it is necessary to further implement and improve these algorithms to find the best results.

Many works are devoted to the transport logistics issues (Pavlenko et al., 2020; Aulin et al., 2020). Thus, Bowersox et al. (Bowersox et al., 2019) describes the role and content of logistics in modern business, as well as examines in detail two fundamental tasks facing managers: developing an appropriate logistics structure and overall management of logistics activities. Stock and Lambert (Stock and Lambert, 2001) focuses on the marketing orientation, and subject matter is reviewed in terms of customer satisfaction. Emphasizing the marketing aspects of logistics, the authors combine all functional business areas, and also include logistics in supply chain management. The compendium (Zijm et al., 2015) presents the latest developments in logistics theory in various fields, as well as case studies. It contains a collection of theoretical topics, practical cases, case studies and project reports. The emphasis is made on knowledge transfer from research to business practices in logistics.

The relevance of the work presented is attributable to the fact that the proposed software product has multidisciplinary scientific and applied aspects: from its research-oriented nature to practical implementation both in the educational process and in the practical activities of industrial and commercial enterprises.

3 MATERIALS AND METHODS

Nowadays higher education institutions are unique in that economists are taught engineering specialties, and future engineers can choose any economic discipline. Some students seek to obtain knowledge of both economic and technical areas at the same time, and while studying in two specialties in parallel, they also use the right to choose their individual learning path. In an engineering institute of Zaporizhzhia National University, teachers and students of different technical and economic specialties work together on the same scientific or educational issue, which allows them to expand their horizons, exchange teaching methods and introduce modern ways in teaching their disciplines. This enriches the knowledge of students of both specialties and improves the quality of education, which subsequently provides them with the opportunity to receive a prestigious profession.

The issue of teaching methods is essentially a question of how to make close contact between the student and the teacher. It is effective to use visualization with various teaching methods as a means of transition from a passive perception of educational material to an active and conscious acquiring of knowledge. In this way, it is easier to comprehend the essence of the technical problem under consideration and the importance of the technical activity performed, as well as to evaluate the optimality and reasonability of the technical solution.

The daily use of algorithms allows humanity to make life easier due to the speed and optimization of tasks. In the 21st century, during the scientific and technological revolution, the use of various algorithms increases almost exponentially, optimizing most production processes. In most cases, it is enough to slightly modify the existing algorithm and apply it in another area in order to significantly increase the benefits of its application. If to highlight the visualization of the ant algorithm (Dorigo, 1992), it would like to emphasize its alternative way in explaining the decision-making theory to engineering students; it also allows economists involved in transport logistics issues to better understand the material.

3.1 Survey of Visualization Technologies

The global network is increasingly becoming the main platform for data reproducing (visualization). This applies in particular to interactive data visualization, which allows users to manipulate their data and graphics in real time. Although this move into the Internet opens up many opportunities for global visualization, it is also accompanied by its own set of problems. For example, how to reproduce large amounts of data in a web browser? To understand the problems of visualization, several types of web animation development were analyzed. The most widely used technologies in this direction are SVG, HTML, Canvas and WebGL (Frain, 2020). The term SVG means “Scalable Vector Graphics”. It is an XML-based format for drawing vector images. SVG offers certain benefits as a data visualization tool, in particular ease of comprehension, since it consists of standard primitives such as rectangles, circles and lines. Due to the simplicity of its use and integration with HTML standards, this format is the most common option for graphics on the Internet. However, despite this, SVG has one major drawback – scaling the number of nodes.

The main advantage of Canvas technology is that since it creates bitmaps, it does not have a trace of memory that SVG has with its nodes. Thanks to this, we can easily draw thousands of data points using Canvas. On the other hand, Canvas is like a black box, because after it has been displayed on the screen, all we have is an image. Separately, it is worth mentioning the fact that the usage of interactivity requires much more complex solutions, however, it can process data animation much more efficiently than SVG. Canvas is a good option when you create a visualization that provides more data points than the SVG could handle.

The advantage of WebGL is its productivity, in which 3D graphics, millions of data and animations can be displayed smoothly (Cantor and Jones, 2012). The downside is complexity because WebGL is the hardest of the work options, mainly due to the low work level (Shepiliev et al., 2020). Most of the visualizations you crave to do on the Internet can be done without the power of WebGL. However, if you are trying to visually represent hundreds of thousands of points, quickly animate thousands of points, or create complex graphics that include 3D perspective computing, WebGL will be almost indispensable.

3.2 Ant Approach to Solving Problems

The ant algorithm models a multi-agent system whose agents are called ants (Blum, 2005). The ant approach is based on three components: a list of nodes passed, called the ant memory (tabu list); visibility, the value reciprocal of the distance between points; and the virtual pheromone trail on the rib. The implementation of this algorithm is based on an approach in which the probability of an ant choosing a specific route at each step is determined by the relation (Shtovba, 2005):

$$P_{\text{ij}}(t) = \frac{F_{\text{ij}}(t)^{a} * N_{\text{ij}}^{\beta}}{\sum(F_{\text{ik}}(t)^{a} * N_{)}\text{ik}^{\beta}} \tag{1}$$

where $F_{\text{ij}}(t)$ is the number of pheromones on this route, $N_{\text{ij}}(t)$ is the length of the ij-th route, α and β are two adjustable parameters that specify the weight of the pheromone trail and visibility when choosing a route. When $\alpha = 0$, the nearest city will be selected, which corresponds to the greedy algorithm in the classical theory of optimization. If $\beta = 0$, then only pheromone amplification works, which entails the rapid degeneration of routes to one suboptimal solution. The new pheromone value pheromone $F(t+1)$ on the path ij is calculated through the old $F(t)$ taking into account the pheromone evaporation coefficient b (Hauswirth, 2012): $F_{\text{ij}}(t+1) = b * F_{\text{ij}}(t) + \Delta F_{\text{ij}}(t)$, $\Delta F_{\text{ij}}(t) = \frac{Q}{K_n}$, where Q is an adjustable parameter, the value of which is chosen of the same order with the length of the optimal route (pheromone value), and K_n is the length of the path between the start and end points.

3.3 Software Design

The developed software design consists of: a configuration file in which all application parameters are set (dimensions, grid colors, etc.); controllers working with the Main-Class(Grid, AntCanvas); systems; auxiliary scripts; the basic Main file working with HTML.

The visualization process works on a large number of ants (agents) and has the ability to change the number of these agents. Moreover, the system supports a frequency of 60 frames per second for a large (over 2 thousand) number of agents. The presented software product provides the user with functions that are accessible from the user interface, such as: building routes on the grid; storage / loading of routes; launch of ant colony optimization (ACO) algorithm and some of its modifications to the search on the grid; comparison of the results of various modifications of the algorithm in time and processor load; storage of reports and screenshots of algorithm.

In view of the fact that the main practical application of the presented method (application) is to find the shortest way for transporting or delivering an Internet package on the network, the user should be given the opportunity to reflect the algorithm on the graph. Since the graph is a combination of arcs and vertices, the basis for the graph is a fixed grid of vertices, and the user, to simplify the work with the application, will be able to build any graph by connecting these vertices arbitrarily. Limiting the user with a fixed grid, we lose the ability to make the graph flexible, but it provides an opportunity to make a visual analysis of the path length without software processing all possible connection options, since it will be more convenient for the user to determine the distance in a fixed grid.

Considering the analysis of all the possibilities of implementing animations in web applications and the fact that the grid is limited by the user's screen, SVG was chosen as the optimal technology. The application is resistant to actions that are not foreseen by the main functionality, and informs the user of a found error in a particular place and in a particular modification. The application architecture is as flexible as possible, which in the future gives developers the opportunity to create modifications to already implemented algorithms without wasting time on visualization.

3.4 Capacity Assessment of the Developed System

The designed application corresponds to the prototypes in design and functionality. The ability to control other parameters of the algorithm was additionally added. They are: the number of pheromones, evaporation, alpha and beta values (1), as well as the ability to hide the visual parts of the algorithm, if they are not needed. This can significantly speed up the program, especially if the user hides the drawing layer of ants. An example of the interface of the constructed program is shown in figure 1.

The constructed graph is designed so that the task for the ACO algorithm is not trivial. Figure 2 shows the optimal and two suboptimal solutions to the problem. Based on the approach proposed by Dorigo and Stützle (Dorigo and Stützle, 2004), a modification of the obtained ACO algorithm is implemented. The re-

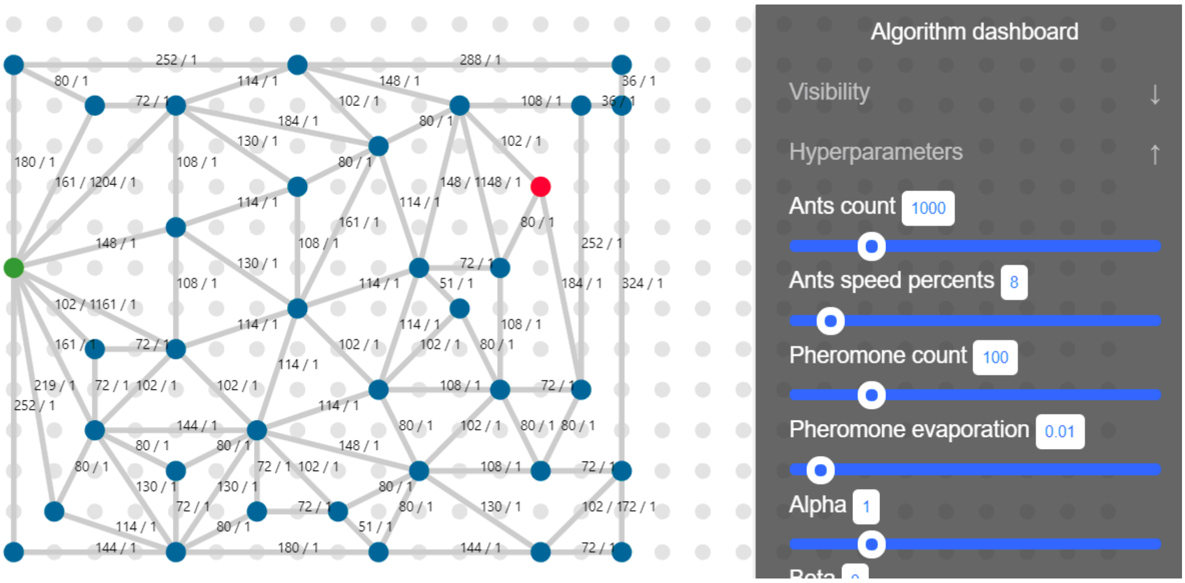

Figure 1: Example of routing task.

sults obtained make it possible to judge the optimal choice of parameters when solving the traveling salesman problem with various initial data.

In figure 3 presents the process of finding the optimal solution to the logistic problem. The created web application helps users better understand the ant algorithm.

Under the present study, a comparative analysis of the application operation and analogue program Simple ACO JavaFx was carried out. To optimize the developed application, passive evaporation was replaced by active one. Such a solution changes the evaporation system from linear to exponential, and pheromone values do not accumulate very quickly, as in a similar program. The results obtained showed that active evaporation is really more effective than passive evaporation; however, in this case, ants began to choose the lower (blue) route more often. It is worth noting that this route has one anomaly – it has the shortest arcs to the start and end points. Thus, it becomes clear that on this short route, ants release more pheromones, which makes the lower route more attractive. To address this problem, a dual strategy was applied to the determination of pheromones. Other than providing a local value, an ant will now remember the total distance covered, and on returning to the starting point, additional pheromone values will be determined by this distance. A comparative analysis of the above solutions is presented in the table 1. The resulting solution is effective in the use of large-scale graphs. The analysis was performed with the same value of ants (1000) and their speed. The comparative analysis of algorithms by value of the resources used in Windows Task Manager is presented in figure 4. The built application consumes 85% at the beginning and then 42% of CPU load, but a similar one consumes 100% at the beginning, and loses a lot in FPS value, and then 51%. Also, a similar program is much worse than the new one in terms of graphics resources: 18% vs 47%. Therefore, the developed solution is optimal from the viewpoint of system resources use and correctness of classical ant algorithms work.

4 RESULTS

The logistics system of an enterprise can be viewed from two sides. Its first important element is the efficiency of the interconnection of the transport system for the delivery of products built at the enterprise. On the other hand, a software product is of particular importance, using which you can train personnel both at the enterprise and implement it in the educational process.

The course “Transport logistics” is an integral part of the training of highly qualified specialists, both technical and economic specialties. Previously, this subject was taught according to the standard curriculum.Today, there are rapid changes in the existing operating conditions of transport companies, so enterprises need specialists who meet the existing high requirements. For this, it is necessary to introduce new practical methods into the teaching methodology of this discipline, which will strengthen theoretical knowledge with practical experience. Since

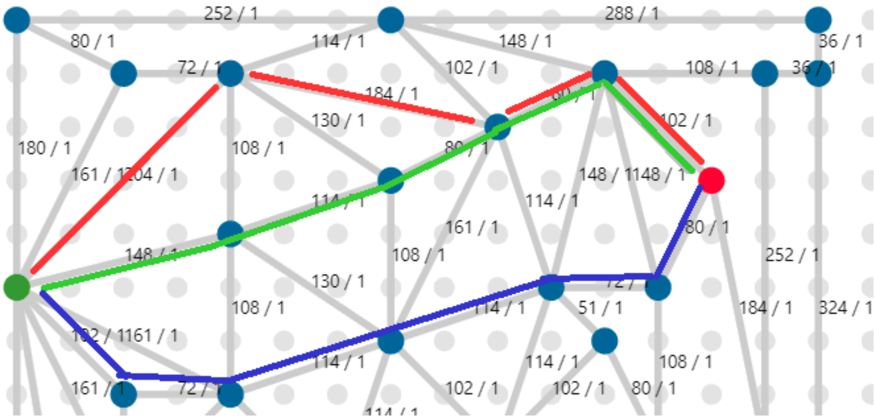

Figure 2: Solution of the routing problem. Red and blue are suboptimal solutions, green is an optimal solution.

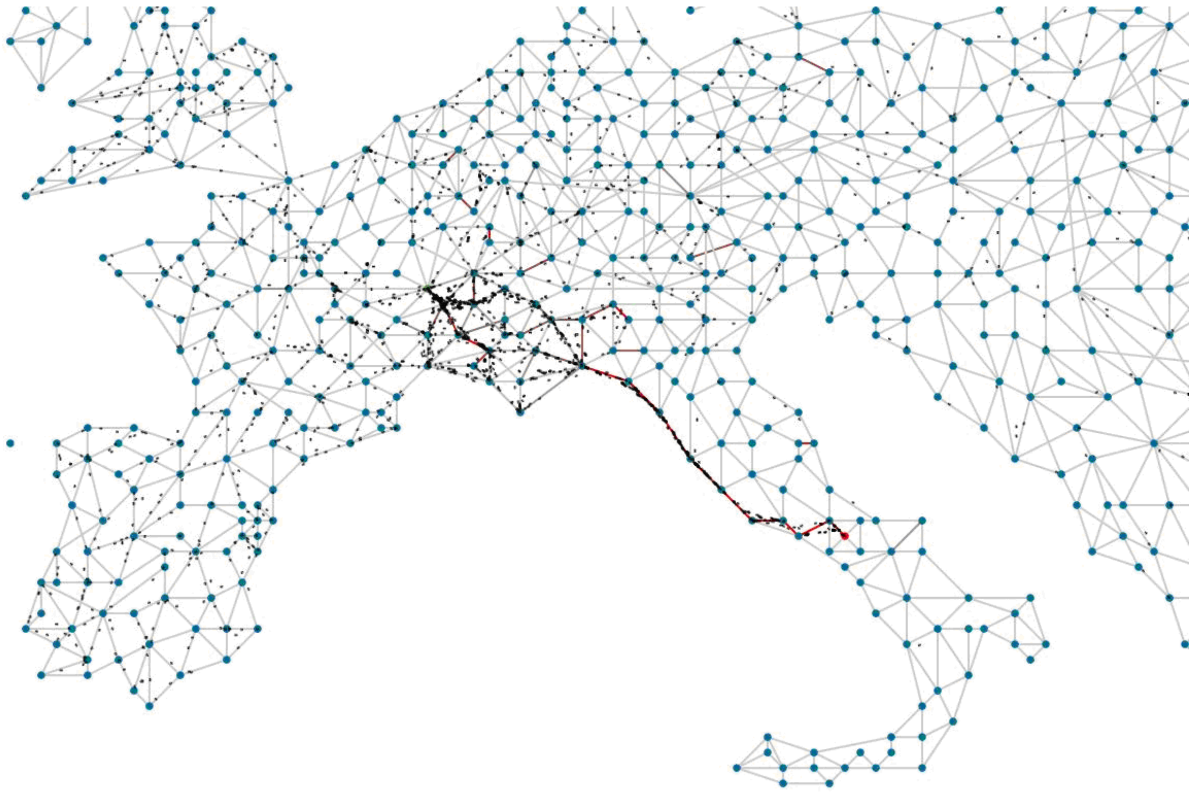

Figure 3: Visualization of the solution of a logistic problem.

Table 1: Relative amount of route selection by different programs based on 100 iterations.

	Upper route	**Optimal route**	**Lower route**	**Other**
Built application	7%	71%	18%	4%
Built application after modification	7%	80%	9%	4%
Simple ACO JavaFx	11%	61%	13%	15%

in our time computerization covers all areas, it becomes necessary to strengthen practical training with the help of modern computer programs.Cooperation with employers in mastering the competencies of today's students ensures, with the help of our professionals, an increase in the efficiency of the enterprises of the Ukrainian economy as a whole.

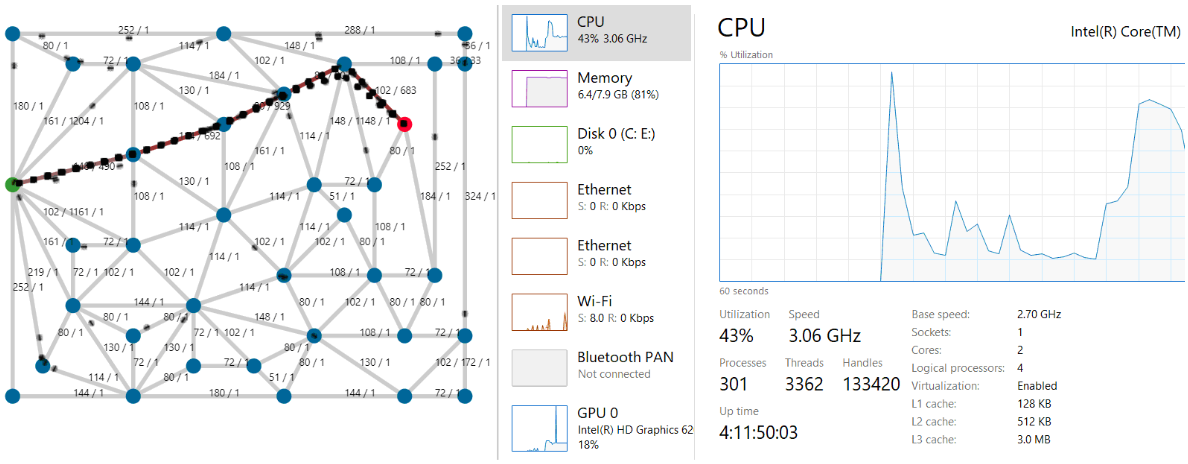

Figure 4: Use of computer resources for the built application.

4.1 Methodical Experiment

A methodical experiment, conducted even under artificially created conditions, is always a training one. The experimental work was carried out on the basis of the engineering institute of the Zaporizhzhia National University. The students of the technical (software engineering) and economic (accounting and taxation) specialties participated in the experiment. At the beginning, the testing was used to study and obtain feedback from stakeholders. Using special survey forms for testing, the desired changes of definite courses in the educational program in order to improve the quality of education were determined.

The survey highlights the need for taking into account the wishes of both employers and students, and also indicates the interest of all participants of the educational process in obtaining relevant competencies, a high level of knowledge and skills based on the learning outcomes. The analysis of survey forms showed that a free choice of disciplines is provided for building an individual educational trajectory for 100% of students. However, a survey of students revealed their desire to change the work program, namely: 30% of students feel the need to increase the number of practical examples, 50% of students want to solve specific tasks, that employers face, in practical classes, 20% of students want to try more other teaching methods in the lessons, 40% of students believe that the material will be better comprehended if during the lessons visualization of teaching methods is used.

After studying the first module by students of the indicated specialties of the corresponding educational programs in the framework of the studied disciplines, namely, "Mathematical Methods of Operations Research" and "Economic and mathematical modeling", the results of a student survey were taken into account and changes were made to the structure of the discipline and its teaching methods.

For the reliability and purity of the experiment, the students were divided into two groups – the control and the experimental. At the second stage, a formative experiment was conducted. It made it possible to identify the pedagogical conditions for the better possibility of solving creative tasks that integrate the knowledge of various disciplines. In the control group, classes in the developed elective course were not conducted and students' desire to solve creative tasks was formed spontaneously. In the experimental group, teaching of the orientation elective course was carried out to form a willingness to solve specific creative tasks arising from employers. Within the framework of the created complex of didactic support for disciplines, students of the experimental group were introduced to modern methods of presenting theoretical and practical material. For a better understanding and information comprehension, the application for visualization of the ant colony optimization algorithm was used as an example in the relevant topics.

At the third stage of work (the ascertaining stage of the experiment), a survey of the participants in the experiment was conducted. The research results of the quality of education, obtained on the basis of the developed survey forms, are presented in table 2. At the end of the study of relevant topics, students of both the experimental and control groups were tested in order to identify the level of assimilation of knowledge and skills for their integration in the study of various academic disciplines, as well as the ability to solve creative tasks.

After the second module, it was noted that in those

Table 2: The results of a students survey of the experimental group regarding the quality of training in the educational program.

Survey of respondents interests	after first module	after second module
Providing interesting discipline teaching	80%	95%
The need for visualization teaching methods	60%	100%
Willingness to solve creative problems	70%	100%
Sufficiency of solving specific tasks arising from employers	50%	97%
Satisfaction with the quality of teaching the discipline	80%	100%

groups where laboratory and practical exercises were conducted with the help of a visualizer, the knowledge, skills and ability to solve creative tasks were found to be 40–50% higher (for various parameters). The satisfaction of students with the sufficiency of the quantity of specific tasks set by employers was almost 50% higher in the experimental group. All students of the experimental groups were ready to solve creative tasks, at the same time, the number of such students in the control groups was about 70%. Thus, a change in the curriculum after clarifying the real needs of students made it possible to increase student satisfaction with the quality of teaching the discipline by more than 20%. In modern conditions, a survey of stakeholders showed how taking into account the opinions of students affects the quality of teaching the discipline and increases the level of students' learning. The results of the experiment emphasized the fact that the teacher conducting a regular survey of students, studying their opinions and, based on their needs, making changes to both their curriculum and the plan for conducting their classes, may create an integrated approach for maximizing the principle of student centrism. Only the orientation on students' interests and needs, provided by a timely survey, allowed us to improve the quality of education of both individual specialties and the educational system at Zaporizhzhia National University as a whole.

4.2 Analysis of the Efficiency of the Logistics System of Enterprises

Based on the information provided by the State Statistics Service in annual statistical collections, we will analyze the transportation of goods by road and freight turnover of road transport in the regions of Ukraine for 2010–2019 (figure 5, 6).

By regions of Ukraine, road freight transport increased from 938.9 million tons in 2000 to 1147.0 million tons in 2019. The analysis of cargo transportation by road in 2019 showed a high demand for it in the regions of Ukraine, namely: Kyiv 51.5 million tons, Cherkasy 34.6 million tons, Kharkov 29.6 million tons, Odessa 28.8 million tons, Lviv 24.4 million tons, etc. However, the forecast of statistics on road freight transport may decrease in the future, due to the introduction of quarantine and periodic restrictions on trade in manufactured goods in stores and the operation of markets, which will reduce the purchase of goods by trade and entrepreneurs.

Meanwhile, in general, we see that the transportation of goods by road is in demand in all regions of Ukraine.

By regions, the freight turnover of road transport increased from 19281.6 million tons per km (tkm) in 2000 to 64952.9 million tkm in 2019. In 2019, the analysis of road transport turnover by regions of Ukraine showed the following activity, namely: Lviv 5150.1 million tkm, Kyiv 4253.8 million tkm, Kharkov 3783.4 million tkm, Odessa 3693.5 million tkm, Cherkasy 2270.9 million tkm, etc. During all periods, there was an increase in the turnover of road transport, except for a slight decrease in 2019 compared to 2018. The structure of road transport turnover shows the following share by regions (directions of movement) of Ukraine, namely: western – 22%, northern – 16%, central – 16%, southern – 11%. Thus, as we see, the freight turnover of road transport has a significant impact on the economy of Ukraine, so an important issue is to build an efficient logistics system in the regions of Ukraine.

Profitability of operating activities as an integral indicator of the efficiency of the logistics system is calculated as follows: $Po = (Op/Gc + Ac + Sc + Oe) * 100\%$, where Po – profitability of operating activities; Op – profit from operating activities; Gc – cost of goods sold (works, services); Ac – administrative costs; Sc – sales costs; Oe – other operating expenses. Based on the annual data on income, expenses and profit of the enterprise, which are given in the Statement of financial results (Statement of comprehensive income), we will calculate the integrated efficiency of the logistics system of Transport Company LLC (table 3).

Analysis of the integrated efficiency indicator of the logistics system of Transport Company LLC for 2010–2019 showed that its indicator decreased from 15.4% to 13.6% every year. Therefore, in 2020, the program presented in the work was introduced, which increased the efficiency of the logistics sys-

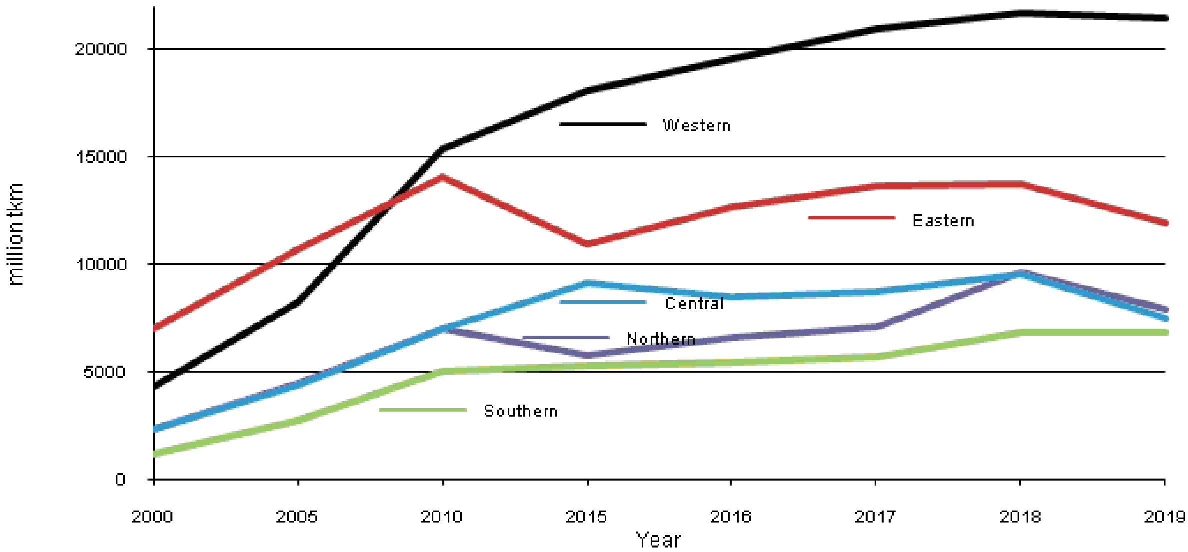

Figure 5: Freight turnover of road transport by regions.

Table 3: Calculation of the integrated indicator of the efficiency of the logistics system.

Indicator	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**
Integrated efficiency index of the logistics system, %	15.4	15.2	15.0	14.8	14.6	14.4	14.2	14.0	13.8	13.6	23.1

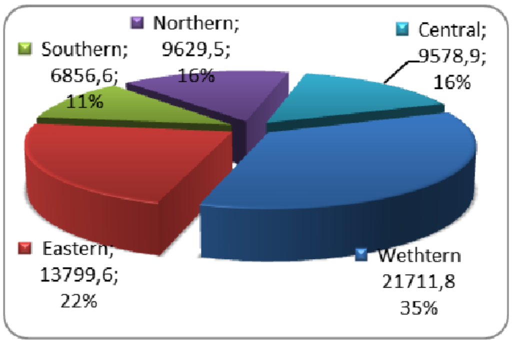

Figure 6: Freight turnover structure of road transport by region in 2018.

tem of Transport Company LLC by 1.5 times. Efficient construction of transport routes significantly reduced the cost of delivery of goods, which increased the efficiency of the logistics system and the company “Transport Company” in general. The developed program is universal, so its implementation is possible at transport enterprises, as well as at private enterprises and state institutions in the regions of Ukraine, which will increase their economic efficiency.

An assessment of the economic efficiency of logistics services can be made by calculating the indicator of the same name, reflecting the amount of logistics costs that are necessary to ensure 1% of the quality of service: $Le = Lc/Qs$, where Lc – logistics costs associated with the execution of a service order in the logistics system, UAH; Qs – the quality of logistics services, assessed by the degree of satisfaction of consumers' requests, %.

The assessment of the economic efficiency of logistics services of Transport Company LLC for 2020 showed an increase in its efficiency indicator by reducing logistics costs and improving the quality of service in the logistics system.

5 CONCLUSIONS

This article analyzes the ways of developing forms and methods of teaching and learning with the aim to form students' creative thinking that helps to increase creative potential. A visualization of the ant colony optimization algorithm is proposed as a means of interactive teaching of students of various specialties in logistical tasks. Full visualization of the ant algorithm, including: graph construction, simulation of a dynamic network (adding and deleting a graph while running an algorithm), visualizing the movement of a large number of ants, saving and loading a graph, giving the user the ability to clean visible layers during algorithm operation for visualization simplification, has been implemented. The conducted comparative analysis proved that with the correct algorithm construction it is possible to achieve strong performance in choosing the optimal routes.

During the experiment to verify the effectiveness of the use of visualization in achieving academic competencies, it was noted that about 40% of students consider it necessary to change the curriculum in the direction of using visualization of teaching methods. After classes, a comparison of the results of the experimental and control groups showed that skills and abilities to solve creative problems were higher by 40–50%. Students' satisfaction with the quality of teaching and the number of solved practical problems also increased by 20–30%, which indicates the positive impact of this interactive method on the educational process. So, to conclude, we can say that the symbiosis of collective work on the study of scientific problems and the introduction of development results into the educational process of the specialties "Accounting and Taxation" and "Software Engineering" made it possible to improve the quality of teaching disciplines. Thus, the use of active and interactive methods in the process of teaching engineering and economic specialties helps to optimize the educational process, increases the informative capacity of the material studied, as well as improves the efficiency of learning.

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Educational Trainings as One of the Effective Forms of Digital Competence Development of Secondary School Teachers

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Keywords: Digital Competence, Educational Training, Online Tools, Practicing Teachers.

Abstract: The article considers possibilities of developing digital competence of teachers by using educational training as an optional form of organization of the educational process and professional development of teachers. Different approaches to the interpretation of the concept of digital competence of specialists, in particular practicing teachers, are identified. Described training as one of the active forms of obtaining knowledge in the system of continuing education of teachers. Given examples of online tools that were used during training sessions for practicing teachers to develop one of the main components of their professional competence – digital competence. Provided static data on the effectiveness of this form of digital competence development, obtained as a result of a survey of participating teachers described in the article of educational trainings.

1 INTRODUCTION

Intensive development of world civilization, global transformation of education, intellectualization of labour, as well as educational realities in a present pandemic, indicate that one of the current issues that needs immediate solution is the lack of proper digital education policy, low digital competence of teachers and students etc.

As stated in the Concept of the New Ukrainian School, one of the tools to ensure success is the end-to-end application of information and communication technologies in the educational process. In particular, it is emphasized that "the introduction of ICT in education should move from one-time projects to a systemic process that covers all activities. ICT will significantly expand the capabilities of the teacher, optimize management processes, thus forming important for our century technological competencies in the student" (Elkin et al., 2017). All this indicates that modern society needs a teacher who has relevant knowledge and is able to qualitatively meet the educational needs of consumers of educational services using advanced pedagogical and information and communication technologies.

However, it should be noted that this is possible only if the teacher is constantly updating his/her knowledge and skills development to teach qualitatively, but at the same time, as noted in the National Report on state and prospects of education development in Ukraine, to learn continuously when "education becomes a means to the aim of human development, which allows to establish its leading role, the purpose of which is to form the skills necessary to perform various functions – self-expression, self-realization, development of social relations and ability to act" (Kremen, 2017).

The active use of information and communication technologies by the subjects of the educational process contributes not only to the informatization of the education system (Fedorenko et al., 2019), but also to the growth of professional competencies of teachers (Bakum et al., 2019). One of the professional competencies that should be formed in the teacher of secondary education institutions is the competence in the field of information technology, the development of which is carried out through the use of integrated di-

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dactic systems, computer, Internet resources and distance learning (Shokaliuk et al., 2020).

The Law of Ukraine "On Education" defines competence as "a dynamic combination of knowledge, skills, thinking, attitudes, values, other personal qualities that determine a person's ability to socialize successfully, conduct professional and / or further educational activities" (Verkhovna Rada of Ukraine, 2017).

Regarding the definition of competence in the field of information technology, there was no unambiguous approach until recently. Scientists often used a variety of terminology: "information competence", "informational competence", "information-digital competence", "digital competence", "information-communication competence", etc. Recently, the term "digital competence" has become more widely used by scholars which first appeared in international documents and is widely used in foreign countries.

The issues of digital competence were covered in (Ferrari, 2011; Kuzminska et al., 2019; Leshchenko et al., 2021; Prokhorova, 2015; Scott, 2015; Vuorikari et al., 2016). In particular, the issues of development of digital competence of a teacher were shown in (Ivanytsky, 2020; Kartashova et al., 2018; Moiseienko et al., 2020; Spirin, 2010; Trubavina et al., 2021).

There are many definitions of digital competence, among them:

- confident and thorough use of information and communication technologies in such areas as work (employment opportunities), education, leisure, involvement and activities in society, which are vital for everyday socio-economic life (Kartashova et al., 2018);
- ability to use digital resources and information technologies, understand and be able to evaluate digital resources and content critically, communicate effectively (Scott, 2015);
- a set of knowledge, skills required to use information technology and digital media to perform tasks; problem solving; information management; cooperation; communication; creation and distribution of content; joint activities and meeting needs (Ferrari, 2011);
- the quality of the specialist, which indicates the level of qualification from basic visual perception and practical skills to more critical, evaluative and conceptual approaches to the use of ICT, as well as includes attitude and awareness in the field of ICT (Spirin, 2010).

In particular, digital competence of teacher is interpreted as:

- knowledge, skills and abilities in the field of ICT and the ability to apply them in professional activities (Moiseienko et al., 2020);
- the ability of the teacher to effectively and efficiently use ICT in teaching and for professional development (Prokhorova, 2015);
- the skill of the teacher to apply information technology in professional activities (Vuorikari et al., 2016), etc.

However, the features and ways of developing the digital competence of practicing teachers have been studied little and require additional research.

The *purpose* of the article is to reveal the possibilities of developing digital competence of teachers by using educational training as an optional form of organization of the educational process and professional development of teachers.

2 RESULTS

The problem of continuing education of teacher practitioners, whose professional activity occupies one of the leading places in the development of society due to modern paradigms of social development, novelty of personal and social requirements to the system of professional education of teachers and their readiness to improve professional development.

In our opinion, special attention should be paid to identifying ways to develop digital competence of teachers in the context of continuing education. Thus, Dryden and Vos (Dryden and Vos, 2005) see the main task of modernity in "preparing all educators in such a way that they know how to combine the best available information technologies in the world with the most advanced teaching methods available in the world and teaching".

One of the active forms of acquiring knowledge in the system of continuing education of teachers is educational training. Training comes from the "to train", which means "teach, train, instruct". At the same time, training is an interesting communication and an exciting process of learning about yourself and others and an effective form of learning, expanding experience and a way to develop skills and abilities (Panchuk, 2015).

Unlike traditional, training forms of learning fully cover the full potential of student: the level and scope of his/her competence (social, emotional and intellectual), independence, ability to make decisions, interaction etc.

The effectiveness of this form of education is due to the fact that (Blinov, 2008):

- the point of view and knowledge of each participant is valued;
- there is an opportunity to share your experience and analyze it in a comfortable atmosphere without coercion;
- there is an opportunity to learn by performing practical actions;
- mistakes can be made that will not lead to punishment or negative consequences;
- there are no assessments and other "punitive" means of assessing new knowledge".

In the framework of the international project "Modernization of Pedagogical Higher Education Using Innovative Teaching Tools" (MoPED) of the EU program Erasmus + KA2 – The Development of Higher Education Potential, No 586098-EPP-1-2017-1-EN-EPPKA2-CBHE-JP participants of Uman State Pedagogical University conducted a series of trainings for teachers of secondary education, regardless of their professional orientation.

According to statistics, the following distribution of teachers who participated in the trainings was obtained. Of the total number of training participants who received feedback, 10% teach in primary school, 54% – in secondary school, 36% – in high school. Among those who teach in primary or secondary school, depending on the subject they teach, we have the following distribution: humanities – 12.5%; social sciences – 2.1%; economic sciences – 4.2%; technical sciences (computer) – 25%; technical sciences (non-computer) – 27.1%; other fields (mathematics, chemistry, teacher-organizer) – 29.1%.

The level of digital competence of participants at the beginning of the trainings was mostly sufficient (38%) and average (62%).

The purpose of these trainings was to increase the digital competence of teachers, acquaint them with modern innovative tools and learning technologies. The topics of the trainings were as follows: "Go-Lab Ecosystem", "Research Learning Technologies", "Computational Thinking", "Development of Digital Competence through Mobile Technologies", "From Classical Lesson to Research Learning", "Research Learning: Creating ILS on the Go-Lab Platform", "Mobile learning technology: the use of Classroom in school practice", "Technology of development of critical thinking in students", "STEM-education: robotics, the use of sensors of mobile devices for physical experiment", "Introduction of Flipped Classroom Technology in educational process", "Technology "Six Hats": the development of critical thinking of students", "Technology "Scribing": a vivid presentation of educational material", "Mentimeter.com – online survey in real time", "Formation of soft skills in students during implementation of the educational process", "The use of multimedia board as one of the requirements of modern educational process in the information society", "Virtual interactive whiteboards as a modern means of educational material", "Distance learning platforms and services" and others.

During the trainings, participants learned how to organize educational activities more effectively, store and create files in cloud storage, automatically evaluate student tasks and effectively organize work in groups etc. The team of trainers demonstrated a variety of free online tools for offline and online classes, for a vivid presentation of educational material, control of students' knowledge etc. Here are examples of online tools that were demonstrated during the trainings and contributed to the development of digital competence of teachers and students.

One of the modern online tools that fascinates students regardless of their age is Kahoot! This is an educational service with which you can conduct interactive educational games: quizzes, discussions, surveys, etc. You can access it through a web browser or the Kahoot app! in Google Play or App Store.

During the trainings, participants had the opportunity to get acquainted with four options for registration on this service: Basic, which is free; Plus, Professional, Premium, which are paid. But even basic (free) access to the platform gives the teacher quite a lot of opportunities:

- allows to involve up to 50 students in testing;
- you can create questions yourself or use ready-made questions from the bank;
- you can enable the function for automatic mixing of answers to the question;
- to visualize the question, you can use a bank of images, add them to questions or use as answers;
- it is possible to limit the time given to the student to answer questions;
- you can determine the number of points for each correct answer;
- allows you to find out how each student answered the questions or build success charts of the academic group.

Free access allows you to create only two types of questions: quiz, namely a question with "multiple choice", when the student is offered several answers and he chooses one or more correct and "true or false" when the student is offered two mutually exclusive answers (figure 2).

The offered service allows to carry out testing in two ways:

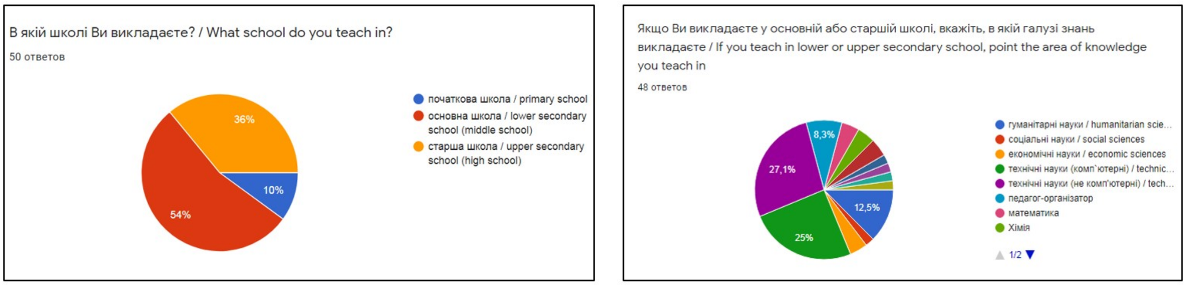

Figure 1: Distribution of teachers who participated in the trainings.

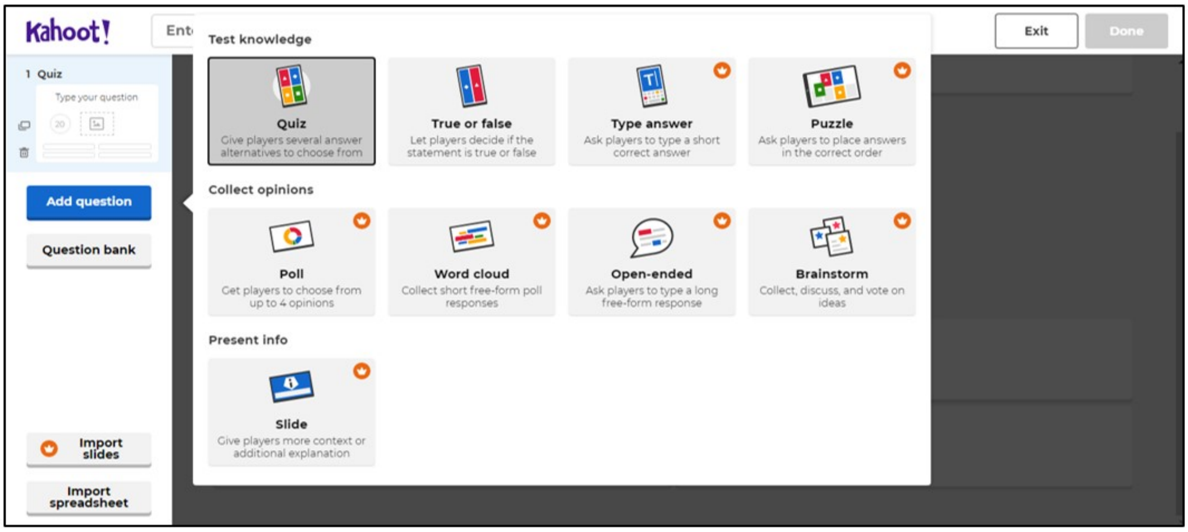

Figure 2: Types of questions in Kahoot!.

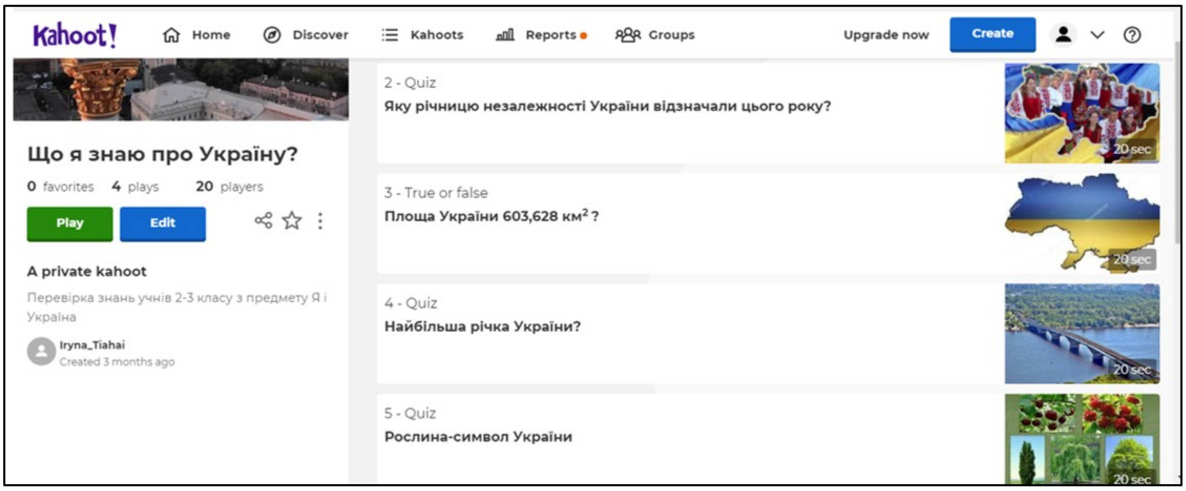

Figure 3: An example of Kahoot! for teachers.

- virtual classroom – testing can be taken with students during offline lessons. In this case, the questions and answer options appear on the projector or computer screen of the teacher and students answer from their mobile phones or computers;
- for self placed learning – students take tests on their own, questions and answer options appear on the screen of their computers or smartphones.

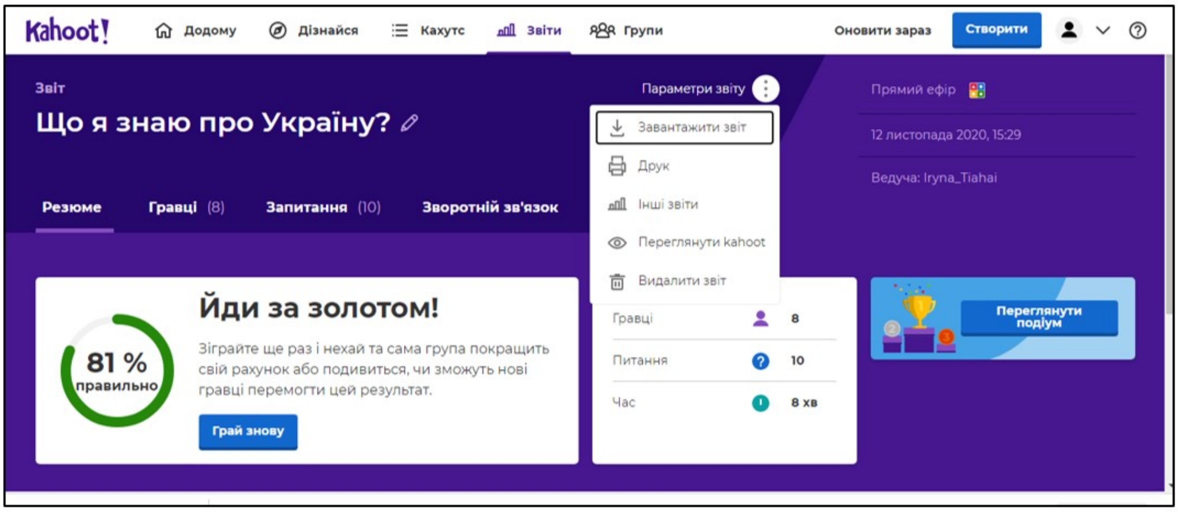

Figure 4: View and download the report.

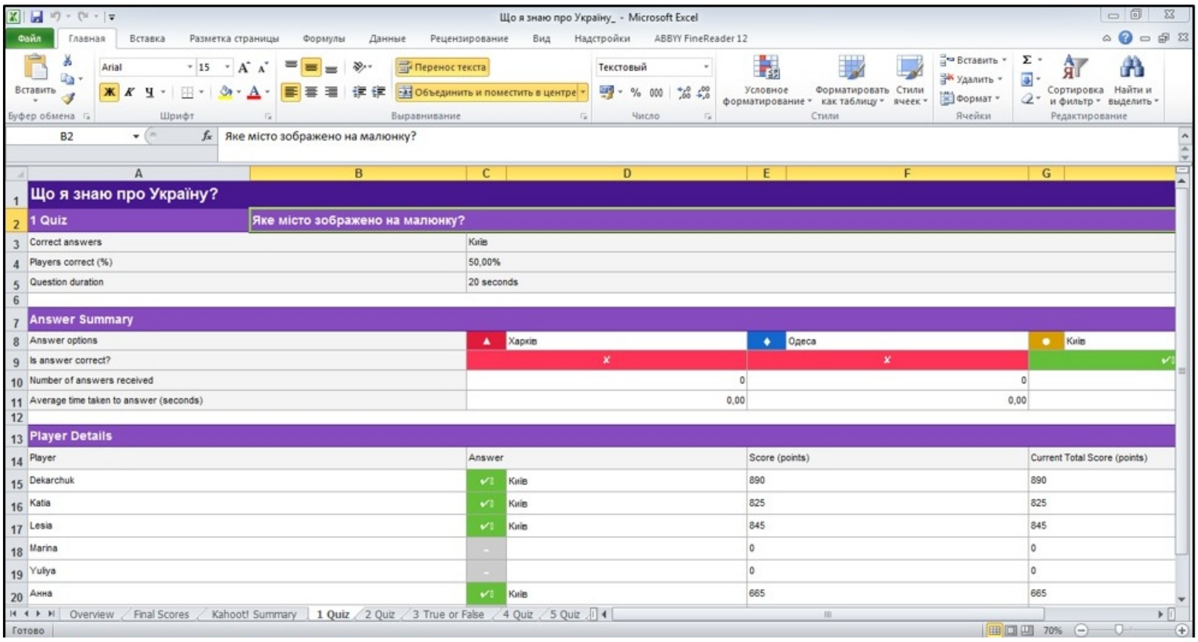

Figure 5: Kahoot! results report in Excel.

By choosing this method, the teacher has the opportunity to set the date and period of time during which the test will be open.

During the conversation at the training, all educators unanimously stated that during online lesson it is quite difficult to keep students' attention when explaining the material. Therefore, the trainers showed that you can try not just to tell the topic with the presentation, but to prepare the Kahoot test! and activate students with short pauses with interesting questions on the topic. Students can take quizzes individually, and it is possible to create competitions where participants receive points for speed and correctness of answers. A small competition will always help make the lesson more interesting.

Since the training was attended by teachers from different subjects, in order to acquaint them with this platform, our team was offered to pass Kahoot! on "What do I know about Ukraine?" (figure 3). The work with this service was as follows: first, teachers took the role of students and passed the quiz, and then, after registration, independently created their own Kahoots in accordance with the subjects taught.

After working with this service, teachers came

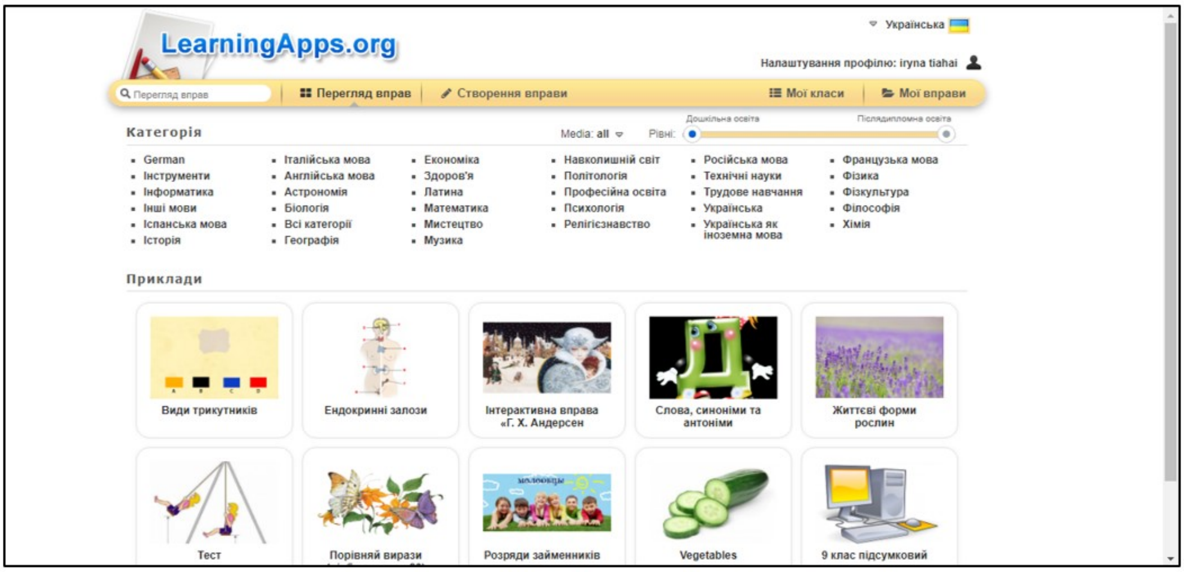

Figure 6: Service LearningApps.

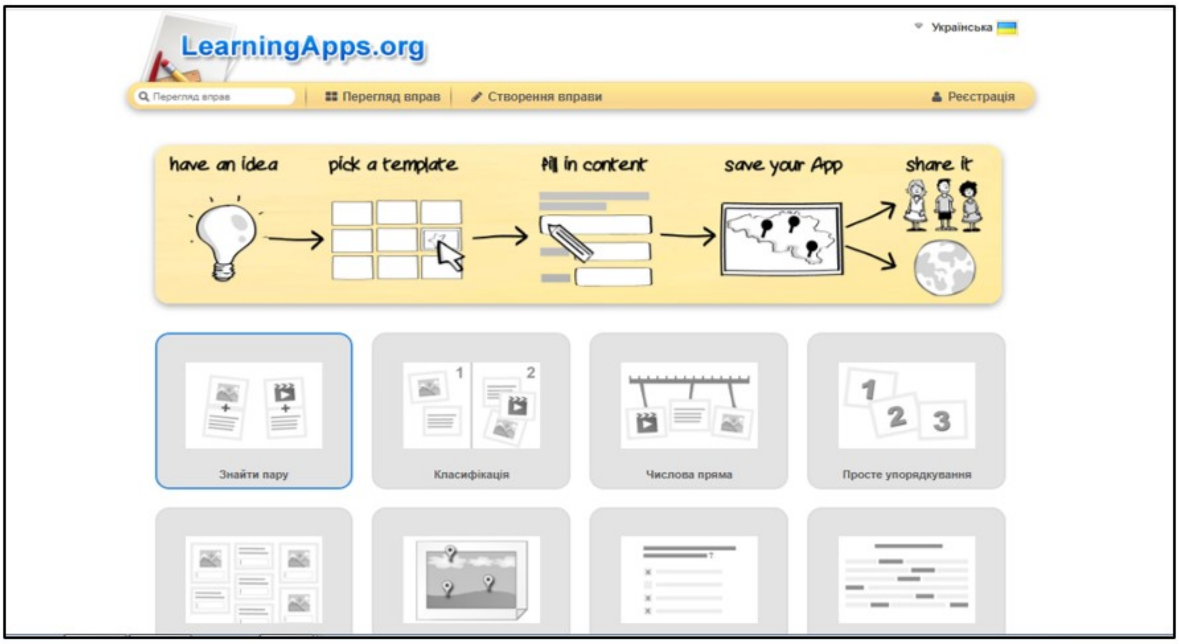

Figure 7: Types of interactive exercises in LearningApps.

to the conclusion that Kahoot! is a convenient tool for creating tests that can be used for: current and thematic control of students' knowledge; self-study and self-control; preparation for tests and independent work; survey of students' opinions, etc. The "virtual classroom" survey method can be used not only for classroom classes or distance learning. It can also be used during student conferences, research groups or other events where there is a need to involve students in discussing scientific or educational issues.

The service allows you to download to Google Drive or PC file (figure 4) with the named results in Excel format (figure 5).

Another online service that allows you to create interactive exercises is LearningApps.org. This service is a designer for the development of various tasks in various subject areas for use in the classroom and in extracurricular activities and for kids and high school

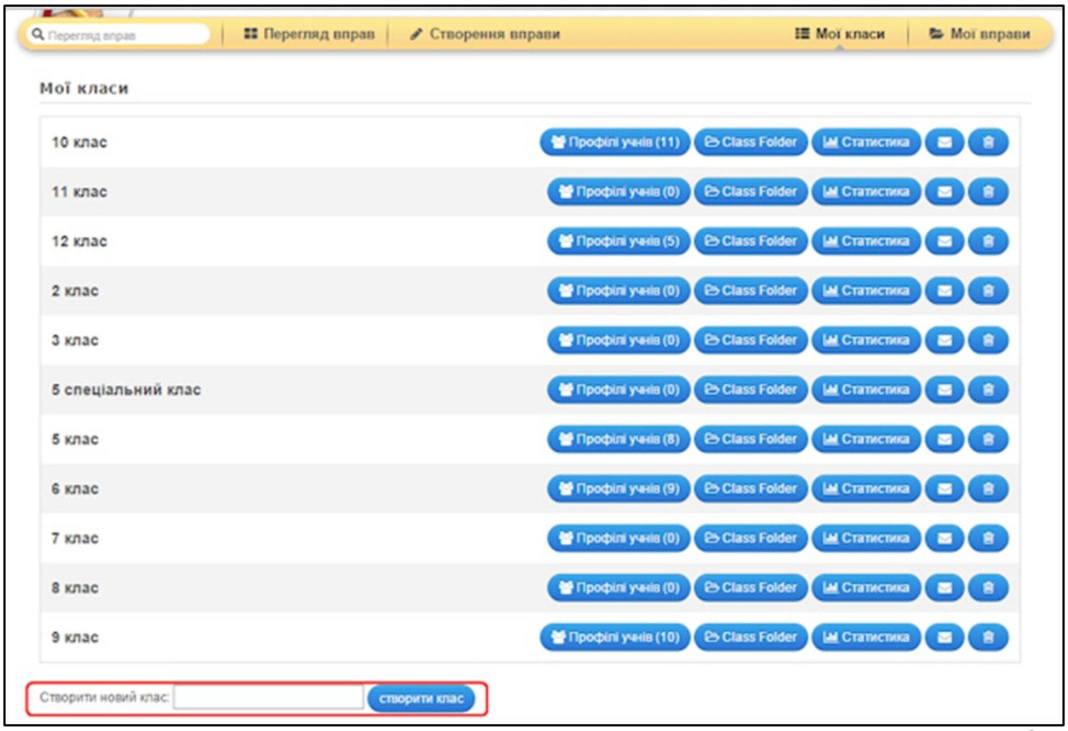

Figure 8: Creating a Class in LearningApps.

Figure 9: The results of the survey of training participants.

students.

LearningApps service is a Web 2.0 application to support educational processes in educational institutions of various types. Designer LearningApps is designed to develop, store interactive tasks in various subject disciplines, through which students can test and consolidate their knowledge in the form of games, which contributes to the formation of their cognitive interest (figure 6).

The service presents many interactive exercises that have been developed for various forms of educational process. During the training, teachers were shown how these exercises can be used in working with an interactive whiteboard, as well as individual exercises for students when doing independent work.

The LearningApps service provides the ability to

Figure 10: The results of the survey of training participants.

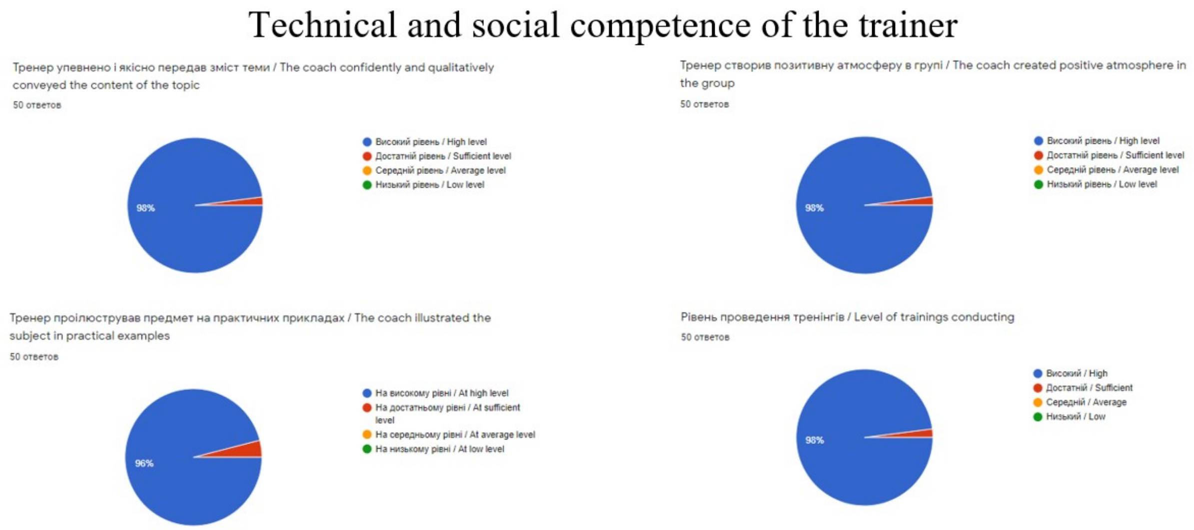

Figure 11: The results of the survey of training participants.

obtain code so that interactive tasks can be posted on the pages of websites or blogs of teachers and students. The trainers emphasized to the participants that each of the resources can be used in their class, changed for their own needs, develop a similar or completely different training module, it can be stored in your own "office", creating your account in this online environment.

During the training, participants had the opportunity to get acquainted with the types of tasks offered by this service (figure 7), to play the role of a student, having already completed the exercise and to create their own interactive task under the guidance of trainers. There are several exercise templates available in each group, the description and samples of which can be previewed before creating your own learning resource.

The participants of the trainings were shown the possibility of creating a Class in the teacher's own account (figure 8), entering data about students, creating a profile for each student, setting a password to log in, etc.

This feature of the proposed service will be useful in connection with the current epidemiological situation in the country and in the world, as the teacher will be able to provide students with tasks remotely and monitor their implementation.

After working with this service, the training participants agreed that the Learning Apps service and its electronic versions of tasks are especially attractive because they allow you to get results almost immediately after the test. Interactive learning tasks help increase the level of digital competence of teachers and students, as well as aimed at solving the most important task of education – to teach school leavers to work productively in the world of global informatization and in connection with global quarantine and the transition of all educational institutions to distance learning which is very important.

In addition to these online services, participants were also introduced to such services as: Mentimetr, Classtime, Plickers, ClassTools, etc during the training. The method of conducting trainings on the use of these services in the educational process will be described in more detail in the following publications.

At the end of the trainings, the participants were interviewed about the general impression of the trainings, the methodology of their conduct and technical and social competence of the trainers. 50 respondents took part in the survey. The results of the survey are presented in the form of diagrams (figures 9–11).

3 CONCLUSIONS

So, the growing role of ICT in education and everyday life requires the formation of digital competence of each individual. This process is entrusted to the teacher as the main agent of action and the engine of modern reforms. That is why there is a question of continuous improvement of their level of digital competence – quality, the formation of which allows teachers at a high professional level to use electronic educational resources to search, logical selection, systematization, use of educational material and effective educational process.

Further research should focus on the use of other innovative technologies, including the ClassDojo, Classtime platform, etc., to increase the digital competence of practicing teachers, as well as to find other training topics for the development of professional competence of educators.

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Practical Activity Organization of Primary School Students with using e-Simulators

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Abstract: Ukrainian primary schools are experiencing significant changes as to Reform 'New Ukrainian School'; it reflects rapid updating of information technology and high level of children's informational activity. Nowadays education has a number of resources to support the teaching and learning for primary school students considering the fact that this school generates the foundation for student's success in the contemporary digital society. Primary schools are basically focused on development of subject knowledge and general study skills. The article deals with the practical activity organization of primary school students with using e-simulators as one of resources for developing subject knowledge and general study skills. The examples of using interactive e-simulators for young learners by teachers-to-be are demonstrated in the article. The research shows that interactive e-simulators provide real task variability, uniqueness of exercises, operative assessment of correction, adjustment of task difficulty, shade of competitiveness and game. The paper presents principles of construction of interactive authors' e-simulators: developed e-simulators should generate learners' interest; be visually presented to create pleasant emotional background; problem definition should involve learners into critical analysis of input data as to their adequacy, redundancy, relevance; e-simulators should allow learners to operate free; the principle of reliance on pedagogical and research tools of personal IT devices means the recognition of the power of modern personal IT devices and their feasibility of use in the learning process as effective and affordable tools of educational and research activities. Based on the analysis of existing experience of using e-simulators in the practice of primary education, we found that for primary school teachers it is important not only the ability to use ready-made simulators, but also the ability to create ones independently, improve them, use knowledge of tools and their functional capabilities, select and formulate tasks for young learners, assess adequately the quality of the developed e-simulators.

1 INTRODUCTION

1.1 Problem Statement

Quarantine restrictions have exacerbated the challenges facing Ukraine's educational institutions. The need for new approaches to teaching with limited number of classes remains a problem for a large part of the educational community. The solution of these issues today is impossible without large-scale introduction of e-learning tools, fundamental changes in approaches to the organization of education in educational institutions and in each discipline, in particular the role of classrooms and the effectiveness of integration of e-learning tools in school lessons (MON, 2020). Against the background of quarantine restrictions, in 2020 the Regulation on distance learning of general secondary education came into force, as well as methodological recommendations for the organization of distance learning at school. The methodical recommendations indicate that the primary level of education needs special attention, because it is the primary school that forms the child's attitude to school education, helps to take the first steps on this path, reveals their talents and natural abilities; affects the

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entire subsequent nature of the student's relationship with the learning environment and society.

The main task of the teacher, within the distance form of organization of education of young learners, is the methodical design of the educational process as a sequence of actions and experiences that students master. In some recommendations (MON, 2020) it is proposed to plan the remote work of students as a cyclical sequence of different activities (including submission of new information, training, practical exercises, etc.), and the forms of interaction should be selected depending on tasks, time and technical capabilities. However, regardless of the form of activity, the level of readiness for practical online activities among primary school students is lower than among secondary school students. There are a number of reasons for this. Let's cover them.

One group of reasons is related to objective factors – age. Thus, the processes of restructuring of mental activity, the transition from visual to verbal-logical thinking, the change of figurative and conceptual, concrete and abstract components just begin at primary school. In this perspective, practical online activities at a particular stage of learning should be feasible for each student. In addition, the distance form of organizing the education of primary school students involves the complication of the information context, the active inclusion of the child in a certain information environment, where any material is a certain interactive information (graphic, textual, associative, video information, etc.). At the same time, due to the individual way of perceiving reality, primary school students have different degrees of readiness to perceive such information online. You can also identify the following reasons:

- limited, and sometimes no experience in the use of distance learning technologies (for example, experience with virtual boards and placing completed tasks on them, etc.);
- limited experience of self-establishment by the student of mobile communication or adjustment of separate parameters of a network and, as a result, a delay in access to e-resources in real time;
- time limits that must be observed when organizing lessons using distance learning technologies. Such restrictions in the organization of practical activities narrow the range of practical skills of students, because some students require additional time, for example, for reflection, reasoning or in case of difficulties require an immediate response from the teacher, etc.;
- untimely correction when students perform practical tasks within distance learning (due to, for example, class size, technical malfunctions), which leads to a delay in the transition of the student to the next level.

The named reasons condition the need for new approaches to implementation of information and communications technologies in teaching young learners. Primary school is focused on the development subject knowledge and general study skills such as skills of writing, reading, doing sums, spelling and others, assured command of which is a prerequisite for further successful studying at school.

Achieving success in building subject and general study skills is a natural need of every young learner. Each child comes to school with an aspiration to be successful and to gain recognition of personal achievements. For a young learner the expectations of success are connected with the efforts to gain recognition on the part of people important for him/her – parents, teachers, principal, classmates and getting approval from them. Experiencing success by young learners affects the quality of education, the development of the inner child's world, the formation of self-confidence.

As we know, success is a feeling of joy, satisfaction from the fact that the result, which the personality was striving for in his work, either matches his expectations, hopes, or exceeds them. Success is always connected with actions, it is not an end in itself. This is the result of achieving the desired goal, accepted, recognized and meaningful to a child, experience of feelings of joy after overcoming difficulties. Achievement provides for getting a specific result, and recognition can be public, local or individual (Romanovsky, 2011). The success supports a child's interest in learning, encourages him/her to overcome the difficulties, urges to achieve new goals.

One of the modern ways of forming a general study and subject skills by primary students are e-simulators, which are educational software designed to shape and consolidate practical skills after preliminary mastering of theoretical data by young learners.

1.2 Recent Work

The literature also holds many studies related to the positive effects of educational use of information and communication technology (ICT) in general (Sipilä, 2014) and cloud technology in particular (Markova et al., 2019); instructional design principles, their interrelationships, overall process of designing effective teaching with ICT (Calloway, 2009; Chemerys et al., 2020), engineering design thinking, teaching and learning with ICT (Dym et al., 2005).

Some issues about primary learning were discussed such as developing technological pedagogical content knowledge in pre-service science teachers (Alayyar et al., 2012; Kovshar et al., 2019); using ICT in primary school curriculum (www.curriculumonline.ie, 2001); e-learning for primary teachers (Hughes and Daniels, 2013), using ICT in distance learning (Rahman, 2014).

We wrote some articles concerning such a significant investment in the theory as didactic potential of digital educational resources for young learners (Olefirenko, 2015; Belousova and Olefirenko, 2013); and in practice as use of GeoGebra in primary students training (Olefirenko, 2013).

1.3 Methods

Theoretical and empirical methods are used in this research. Theoretical methods (analysis and synthesis) serve to analyze opportunities, advantages and disadvantages of e-simulators as new means of practical activity organization of young learners at primary school. Empirical methods (observation, testing, pedagogical experiment) provide the experiment itself, detailed and achievement tests in order to collect data for examining the efficiency of use systematic e-simulators at primary school.

2 RESULTS

2.1 Interactive Teaching Tools in Ensuring the Success of Young Learners in Practical Activities

To educate young learners there are many e-simulators developed that facilitate the acquisition of skills in Maths, in ICT, in native language, in foreign languages, etc. However, e-simulators are relevant if it allows you to work out exactly what caused the difficulty at a particular lesson, when the specifics of teaching material is taken into account, especially the perception of young learners.

E-simulators unlike traditional manuals provide real variability of interactive tasks, uniqueness of exercises designed to form appropriate skills. In particular, for training young learners in performing calculations and doing sums, e-simulators are able to generate an unlimited number of numeric values to each task type, which allows diversifying the learning objectives, avoiding memorizing answers.

The advantage of using e-simulators during both traditional and distance learning of primary school students is to provide an opportunity to expand the possibility of presenting educational tasks aimed at primary school students – to present tasks in schematic, tabular form (figures 1, 2).

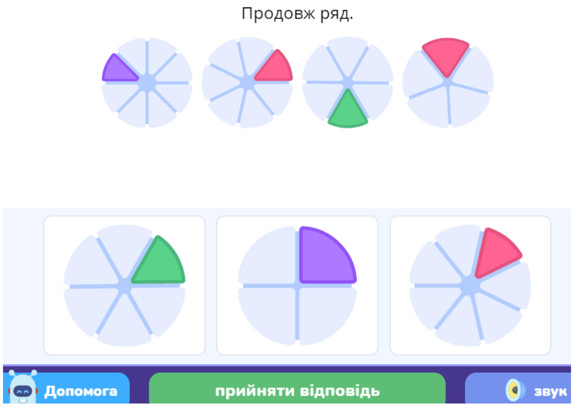

Figure 1: The task of logical load "Logiclike".

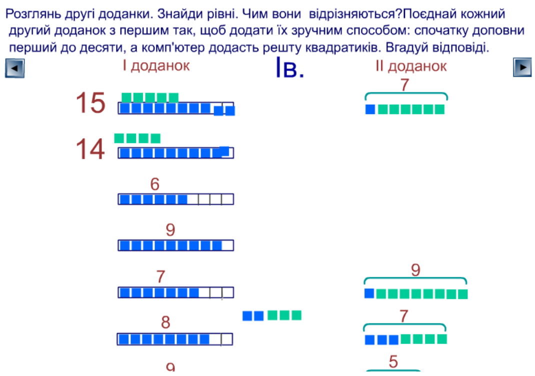

Figure 2: Exercise for addition "Samouchka".

An important feature is the adjustment of task difficulty (figure 3). The difficulty level can be preset designated by a teacher or selected by a learner, can have several ways of solving (each time you can increase the level of complexity of tasks, offer solutions to examples that require guesswork, intelligence (figure 4), thereby stimulating the intellectual feelings of young students).

Of particular interest there are e-simulators that implement adaptive algorithms and basing on learners' performance of first proposed tasks adjusts automatically the level of subsequent tasks. Such adaptive interactive e-simulators are useful especially in primary school, because the difference in learners' background, in level of their habits and skills is the most notable among children: in a class there are those who perform calculations easily, read quickly, etc., and those who are only acquainted with basic rules, learn to form syllables.

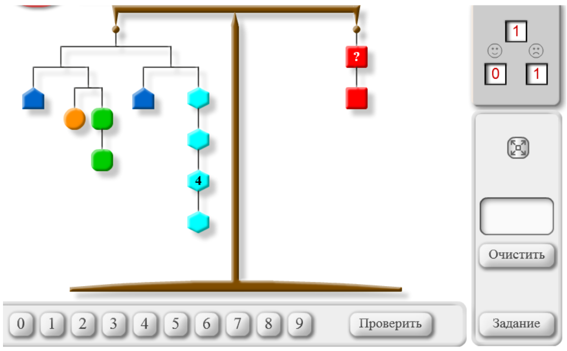

Figure 3: Scheme in “Maths-and-games”.

Figure 4: The complex of educational games “Learn”.

Automatic control of the difficulty level of tasks enables a teacher to identify gaps in learners’ knowledge and eliminate them quickly. To learners whose skills are already formed at a high level, e-simulators provide an opportunity to test their skills doing exercises of increased difficulty. Thus, tasks for each learner are in the zone of their proximal development.

E-simulators feature the ability to provide a shade of competitiveness and gaming to the exercises. It is worthy of note that game is not the main activity for primary school children, but it takes a significant place in child’s life along with educational activities. Playful learning requires substantial intellectualization of primary school child’s activities such as prompt realization of task, analysis of possible solutions, and search for the optimal variant. Moreover, the game encourages a learner to show initiatives, to develop activity, stimulates memory development, initiative thinking, releases emotions.

Using computer can realize the benefits of playful learning to the full extent. Exploring the specifics of computer games in education, there are the benefits as we know: increase learning motivation, encouragement of initiative and creative thinking, inclusion all learners into activities, getting experience of cooperation and teamwork, establishment of interdisciplinary connections, creation an informal environment for learning, favorable conditions for different strategies formation for solving problems, etc.

The emotional appeal of computer games, competitive game aspect, and variety of events, exciting plot, realistic graphics, and ability to control characters by oneself can instigate learners to achieve only a gaming purpose. Therefore, an important prerequisite for using computer games in education is to provide conversion of a gaming purpose (to help the character, to win, to release someone, to get the prize) into achieving educational goals. For example, within the electronic simulator “PilasBloques” students are asked to compile software code for a virtual hero, which will allow you to manage it (go a certain number of steps, say hello, etc. (figure 5).

Digital Mathematical Platform “Matific” contains simulators in Mathematics, focused on the organization of practical activities of students to add decimal fractions through visual models (figure 6), adding three-digit numbers and more. Playful presentation of a task, its dynamic nature, the practical purpose (to color a picture, to collect garbage, feed the cat, etc.) turns a routine work on developing skills into an interesting game that motivates learners to perform typical tasks. In addition, ability to compare the results of their own work with other learners’ ones, gives such activities as sport excitement and an incentive to improve the obtained results.

Among the advantages of using electronic simulators for the organization of practical activities of young students during both traditional and distance learning, we also single out the provision of opportunities:

- to provide systematic practical work on solving by students a large number of similar tasks in a short time (figures 7, 8);
- providing an opportunity to organize the activities of each student on its own trajectory, depending on his skills, knowledge, the need to deepen knowledge;
- providing timely assistance (which may be implicit, upon request, provided by the hero of the program, who accompanies and monitors the long delay in the exercise, etc.).

It should be noted that the peculiarity of the use of electronic simulators is the rapid assessment of student actions. Immediately after completing each task, the child may receive an appropriate reaction, which will indicate the correctness of the solution

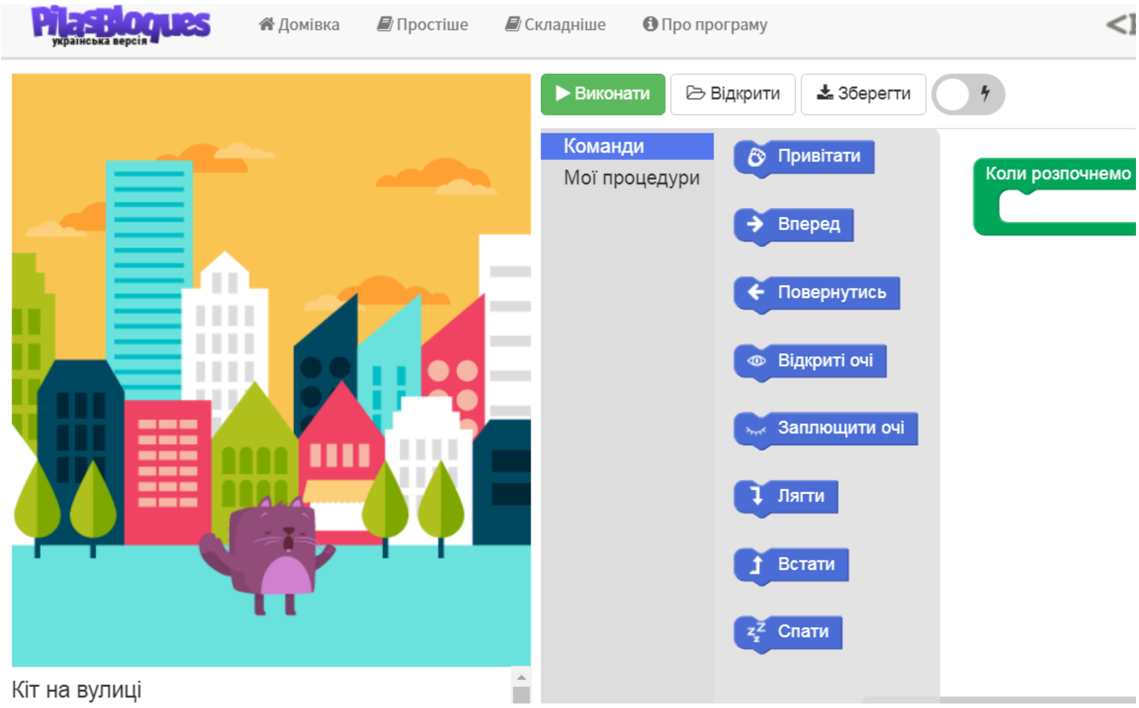

Figure 5: E-simulator “PilasBloques”.

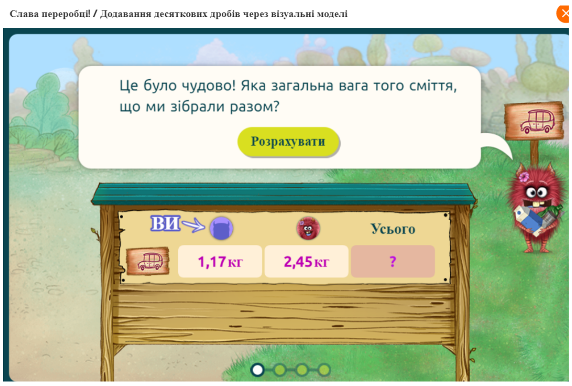

Figure 6: E-simulator “Matific”.

(figure 9). Such an immediate reaction is important when organizing the practical activities of young students with electronic simulators, because students expect approval for successful completion of tasks or some kind of support in case of errors. The immediate reaction of the electronic resource will help increase the student’s confidence in their abilities.

There are some principles of construction interactive authors’ e-simulators. With the development of tools, the availability of information sources a teacher-to-be is able to create interactive authors’ e-simulators that take into account the specifics of training learners of a particular grade on a particular topic, their individual characteristics and hardware of educational process. Authors’ e-simulators can be directed to practice exactly the skills that cause difficulties for learners.

2.2 The Principles of Construction Interactive Authors’ E-Simulators

Based on the analysis of existing experience of using e-simulators in the practice of primary education, we have identified the following principles of their construction to ensure successful teaching primary students.

The first principle to be taken into consideration at e-simulators design is the following: *developed e-simulators should generate learners’ interest*.

The matter is a child who works with an interactive model is unobtrusively involved in educational and cognitive activity. It is important to emphasize that a learner is got involved in this activity not by direct teacher’s instructions, but on his own desire to resolve the situation occurred on a computer screen. Plot design of a training material encourages him/her to educational activities. These actions require revealing subject knowledge and skills as well as the ability to apply them to a new environment. The combination of training and practical purpose that is achievable and understandable for a child gradually transforms into the learning motive. Such a transformation is promoted by the circumstance that at summarizing

Figure 7: Simulator "Educativ".

the child's work with a didactic model, his attention is focused on the importance of the knowledge and skills that have helped to achieve a successful outcome (Belousova and Olefirenko, 2013).

In primary school it is crucial to include pure life realities into the learning content. It provides implementation of the didactic principle of training and practice connection.

E-simulators must allow to apply a learning task with all its attributes: for example, travelling cars, a chocolate bar that is being eaten, a pie which is being divided etc. A learner can move the car, divide the chocolate bar, cut the pie in different ways.

E-simulators allow to expand the diversity of training tasks, suggesting the problem having various solutions. So, a learner is assigned not only to solve the problem correctly, but also to make a rational choice of the solution method. The second principle to be taken into consideration at app design is the following: *e-simulators should be visually presented to create pleasant emotional background*.

Child's emotions at classroom activity have a significant impact on it. Emotions initiation of primary schoolchildren usually is associated with a particular situation. It might be nice visual design, familiar objects or characters, valid comments. All this calls up a learner's pleasant feelings.

Development of positive emotions and aesthetic senses is also promoted by the series of techniques. They include friendly interface of didactic interactive models, harmoniously picked up colors, using special techniques to attract and focus learner's attention, to develop his imagination, thinking, and memory. A positive emotional background of a child's learning with interactive models is also guaranteed by the possibility to cancel his actions at any moment and to return to the previous step. A learner has an opportunity to feel free doing his trials at searching right or effective task solving. He is not afraid of any negative consequences. It promotes creation of a learner's positive emotions, forming his persistence and confidence. The third principle to be taken into consideration at e-simulators design is the following: *problem definition should involve learners into critical analysis of input data as for their adequacy, redundancy, actuality*.

For this purpose, the developed e-simulators have redundant information, so that a child could choose what he/she needs. For example, additional measurements, additional data etc. The fourth principle to be taken into consideration at app design is the following: *e-simulators should allow learners to operate free, for example, to perform transformations of geometric solids (rotate, drag, resize them)*.

The peculiarity of young learners' perception is a close connection with an action. For schoolchildren,

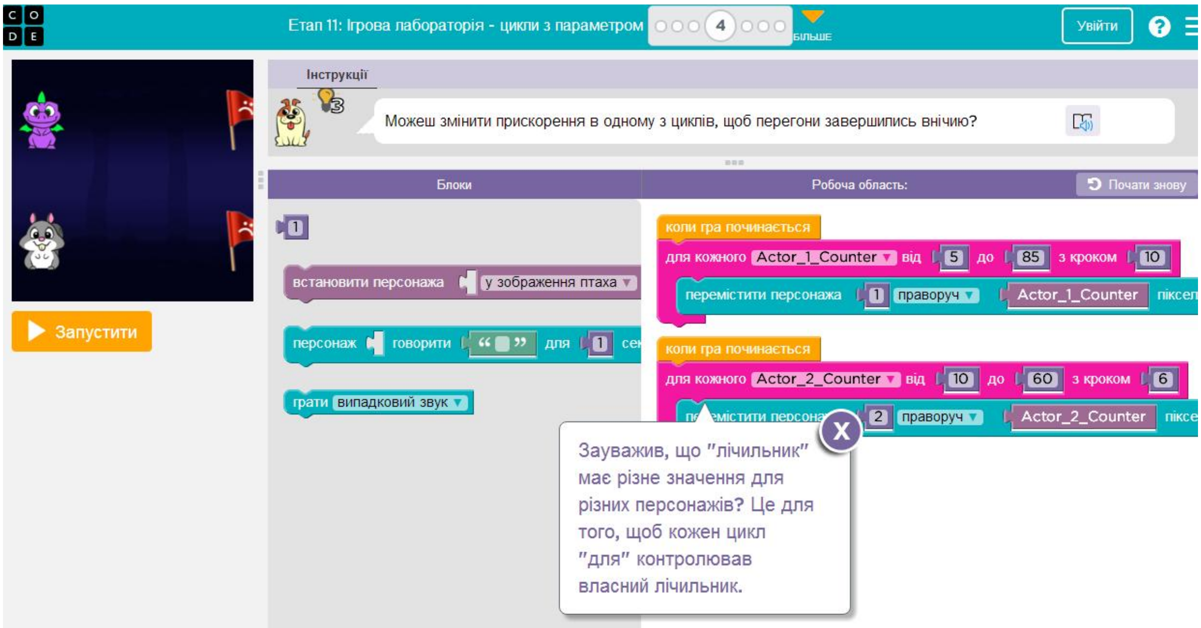

Figure 8: Simulator "Code".

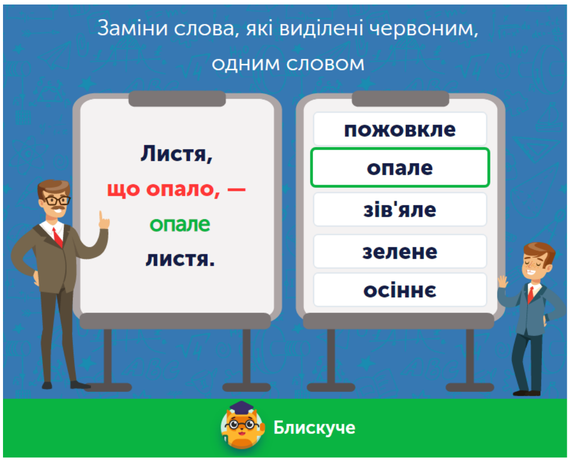

Figure 9: Tasks for 4 grade students "Learning".

especially at the age of 6–7 years old, to perceive the subject means to do something with it, for instance, to touch, to rotate, and to change. Practical actions play a significant role for the development of child's cognitive processes. Therefore, e-simulators should allow manipulation with learning objects.

E-simulators which are focused on learners' research activities should provide possibility of the figures transformations such as rotation of geometric shapes, overlapping some shapes on others for their comparing and resizing. Making changes with shapes meets child's need to experiment. At the same time it allows to see results of his activities and to make his/her own conclusions.

The fifth principle is the *principle of reliance on pedagogical and research tools of personal IT devices* means the recognition of the power of modern personal IT devices and their feasibility of use in the learning process as effective and affordable tools of educational and research activities. Note that this principle is one of the main in the further organization of the practical activities of primary students with e-simulators, because today smartphones and tablets have become an integral part of modern children's lives. The implementation of the principle involves the use of educational mobile applications, through which the teacher has the opportunity to organize independent practical activities outside the school. To date, a powerful database of e-simulators has been developed, some of which are available on mobile applications. Such mobile simulators provide a real opportunity to organize a multi-level (individual) approach within the lesson and during the organization of distance learning, provide instant verification of the correctness of the tasks; provide opportunities to organize the practical activities of each student on their own trajectory, depending on his skills, knowledge, the need to deepen knowledge. For example, the applications "Lightbot: Code Hour" (from SpriteBox LLC), Programming for children (from IDZ Digital) are focused on supporting the topic "Performers of algorithms and their command systems" (figures 10, 11).

It should be noted that the practice of students' knowledge gained in class is a normal process. At the

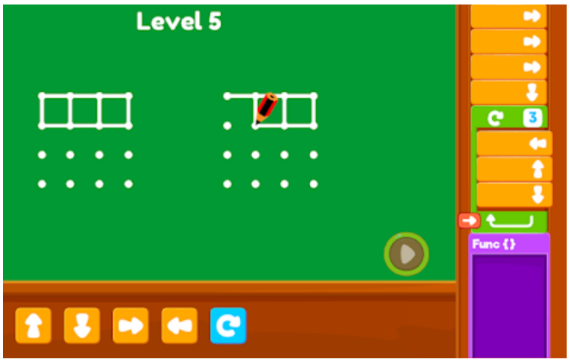

Figure 10: The complex of educational IT devices' games "Programming for children".

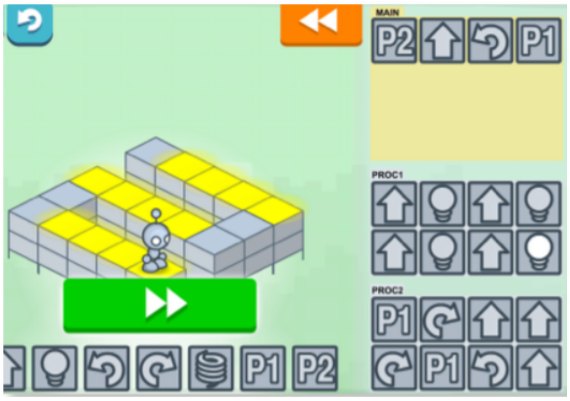

Figure 11: The complex of educational IT devices' games "Lightbot: Code Hour".

same time, the organization of practice, consolidation of knowledge sometimes loses its didactic value due to the formality of this type of work, the uniformity of educational exercises. That is why the advantage of using in educational practice such educational applications as "Lightbot: Code Hour", "Programming for children" gives students the opportunity to practice learning methods in a variety of game learning tasks; attractive, expressive form of presentation of the material; availability of various forms of encouragement and provision of timely assistance to educational institutions, which provides an activity approach of students to the acquisition and consolidation of knowledge.

Some additional principles to be taken into consideration at interactive models design are: developed e-simulators should provide support (step by step assistance) of learners' activity to achieve success and completeness at tasks performing; developed e-simulators should provide an opportunity to verify the correctness of the obtained result.

On the one hand, to succeed in learning it is important for a child to have an opportunity to achieve his intended result. Timely assistance is crucial for learners who have just started learning. Developed e-simulators contain elements that provide necessary support for a learner. Every child who works with the model can get help in time. A child can get help after his request in the form of textual commentary, additional constructions, and solution. The system of multi-level assistance in E-simulators focuses on achievement the result by each child.

On the other hand, training should be accompanied by overcoming difficulties feasible for a learner. Depriving a learner of difficulties we, however, deny him feeling joy and pleasure of success gained through his/her own efforts. Difficulties in the learning process are essential to meet learner's needs in cognitive activity. Therefore, learner's assistance at difficulties should be dosed, not excessive, but sufficient to support his efforts and aimed at making him/her overcome obstacles himself/herself. Learners in their learning activities should not act on a pattern and algorithm and retain the right to initiative, possible errors and their correction. A learner should be relaxed in his own actions. The experience in this activity is now appreciated higher than well learned rules in solving typical tasks as this experience teaches a learner how to acquire knowledge.

Taking dosage help for learners in e-simulators is a complex task and is currently being implemented fairly rarely, but this assistance will help developing initiatives to identify creative abilities, creating strong-willed child. Successful and progressing schoolchildren can employ maximum available to overcome difficulty level tasks for schoolchildren.

2.3 Interactive Tools for Construction Authors' e-Simulators by Primary Teachers-to-Be

We would like to show the basic tools for construction interactive authors' e-simulators. A teacher-to-be, creating e-simulators, independently, can use modern tool kits to create interactive exercises and didactic computer games. The interface of many tool kits, oriented to design author's didactic resources, is simplified and intuitive for an average user and it does not require additional training. In addition, as a rule, these tools include a set of templates for rapid development and offer the available examples.

To develop e-simulators a teacher-to-be can use programs that are part of an integrated Microsoft Office package, spreadsheets and applications to create presentations.

The choice of these applications is due to several reasons:

- wide spread of Microsoft Office package among different specialists;
- preparedness of teachers-to-be to use office technology in teaching;
- presence of large collections of teaching resources developed by teachers for their own educational activities. Ready didactic resources are available to teachers and can be adapted to the conditions of a particular grade and lesson;
- teachers' experience of usage software package for the preparation of teaching and learning materials, documents, etc.;
- possibilities to integrate various forms of information in e-simulators, so, slide or book may contain author's drawings prepared in appropriate graphics software, sounds, prepared in music editors, text fragments.

There are the examples of authors' e-simulators. Electronic simulators developed by our students from H. S. Skovoroda Kharkiv National Pedagogical University, teachers-to-be for young learners for primary school to teach Maths in Microsoft Excel spreadsheet are presented in the form of tests, didactic games, crossword puzzle (figures 12-14).

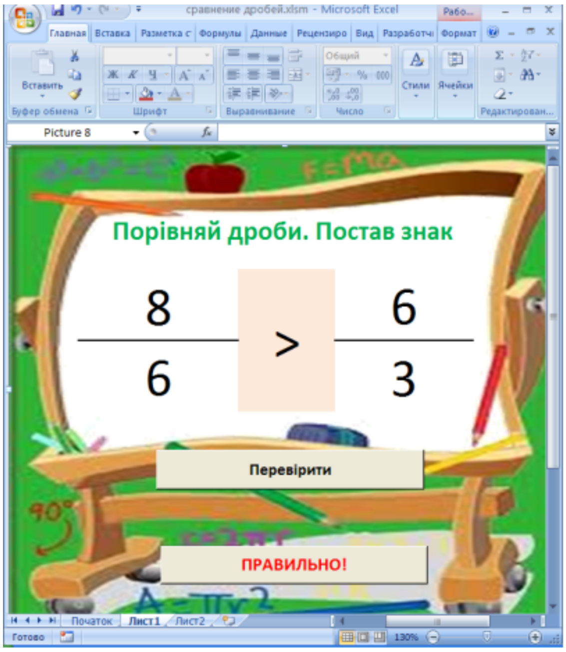

Figure 12: E-simulator for learning fractions developed in Microsoft Excel.

Basically, such capabilities provide convenience to create training systems in Microsoft Excel:

- data exchange between applications which facilitates the process of preparing the environment for

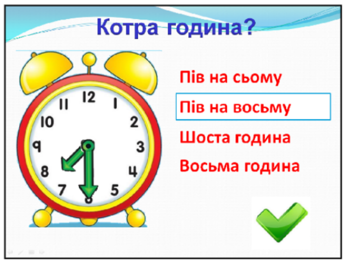

Figure 13: E-simulators for learning analog clocks.

Figure 14: E-simulators for learning multiplication tables.

e-simulators and enables to provide an attractive appearance;

- modifications and additions to the tasks when they are needed;
- programmable generation of numerical values in the text of tasks and answers. This allows preventing memorizing the answers by learners and provides variation of the tasks.
- simplification of the analysis of the assignment correctness by the relevant functions;
- presentation of the test results in the form of tables, charts, graphics, etc.;
- storage of test results and the ability to further analysis;
- availability of templates to create tests that are available to teachers-to-be at any time.

The advantage of using presentation software to develop automated tests is the possibility of their attractive design, providing a soundtrack, the ability to support each task or question with a desired scheme or pattern. In addition, the PowerPoint environment allows the construction of matching tasks, where the correspondence between the elements of two sets is defined, the tasks of ordering the sequence of actions.

Of special convenience for a teacher-to-be is the access to ready-made templates that have a pro-

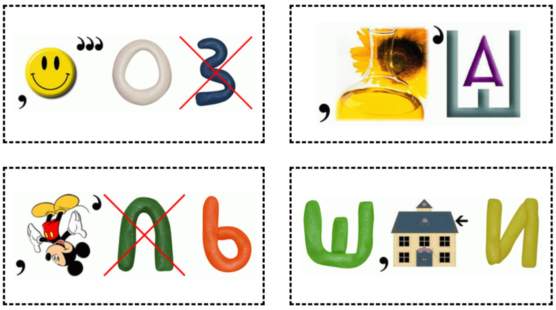

Figure 15: The complex of educational games “Rebus1”.

grammed tasks check. In the environment of Microsoft PowerPoint presentation the electronic simulators developed by our students are presented (figures 14, 15). The e-simulators include controls designed for automatic creation of tasks for learners and elements that analyze user actions.

However, the development of electronic simulators in these packages requires knowledge of the programming language Visual Basic for Application and it is a painstaking task for a teacher-to-be. To create e-simulators primary school teachers-to-be can use designing environments which include a substantial set of templates and patterns associated with school material. In particular, such app designers can be useful for a teacher-to-be. They are the designers: Classtools.net, Rebus1.com, Zondle, Learningapps.org, Studystack, and others.

Within the environment “Classtools.net” (http://classtools.net/) a teacher-to-be can develop interactive posters, charts, diagrams, computer educational games to support any school subject such as Maths, Science, Reading and more. The environment is an online resource that offers a set of templates for creating teaching tools. In particular, enables to create computer games such as quizzes in the form of arcade games (search for pairs of questions and answers, hitting the target with the answer), creates tasks related to the grouping of elements, allows to create interactive posters in which an explaining text is shown when you hover your mouse on a specific part of the image. Of special convenience for teachers-to-be is that developed e-simulators can be stored on the server for the organization of joint work of learners, on the local computer for future use in the classroom, or printed out.

An interesting experience is the work of young students with puzzles. For example, the Ukrainian-language puzzle generator “Rebus1.com” (http://rebus1.com/ua/) allows the teacher to generate any puzzle on a specific request (word, phrase). Within the environment, you can create special puzzles for the first-second grade students, using fairy-tale, and cartoon characters (figure 15).

Despite the fact that puzzle tasks contain images that are easy for students to understand, their interpretation requires a number of mental actions: to determine the main / secondary information, to explain the meaning of the word (text fragment), to establish cause-and-effect relationships, to establish an algorithm, provide a description of the object, explain the purpose of the object (process), draw conclusions, etc. The advantage of using computer puzzles is that independence in such work is achieved due to the instantaneous reaction of the software to the actions of the student, because if students have some difficulties, the program provides additional guidance. The correct solution of tasks is accompanied by various forms of encouragement – appropriate musical accompaniment, approving gestures of the main characters of the program. Promptly and timely individualized assistance and various forms of encouragement stimulate to solve problems of higher complexity, cause the student a positive attitude to independent practical activities.

The didactic games designer “Zondle” (http://www.zondle.com) allows a teacher-to-be to create e-simulators for any subject. The designer offers template games to fill in with the subject content. In this case, a teacher-to-be needs only to prepare assignments and choose a template of the offered. Designer offers to use certain types of tasks, among them the tasks that include:

- select the correct answer from the offered;
- enter the correct answer from the keyboard;
- confirm the correctness of a statement;
- insert missing words into the statement and others.

The environment also provides an option to develop the game plot, choose the characters and fill in substantive tasks by oneself. Creating author’s games does not require programming and additional training. The developed educational games are stored in a network that allows to use them in extra-curricular activities for learners.

The designer of interactive exercises “LearningApps.org” (learningapps.org, 2002) (http://learningapps.org) allows you to create training exercises that require practical actions from user: to place in the correct order, to choose the correct answer, to solve a crossword puzzle, to solve a puzzles, to group etc. Many templates are offered to a teacher-to-be as well as a set of ready-made interactive exercises that can be used as templates (figure 16). They help in creation of such didactic exercises that would be appropriate in a particular

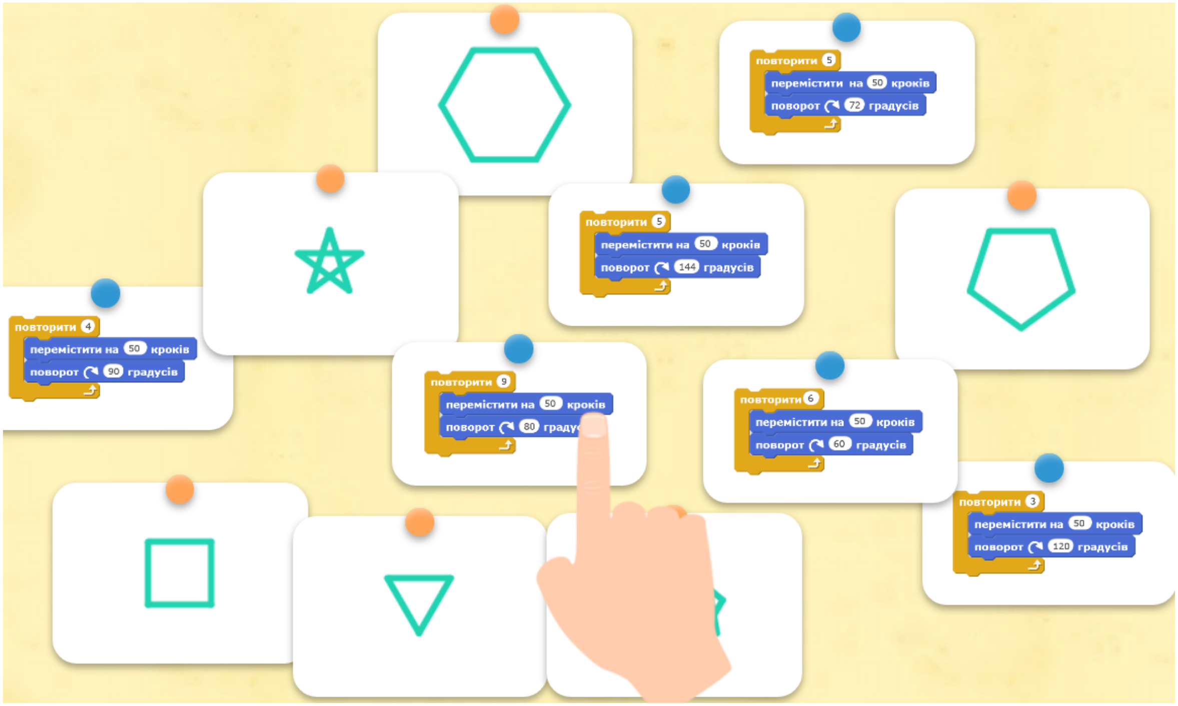

Figure 16: Examples of interactive exercises “Algorithms with cycles”.

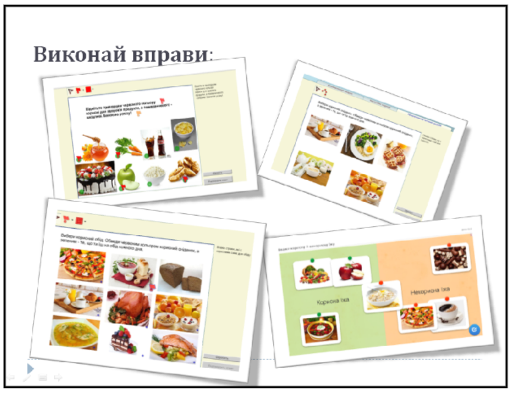

Figure 17: Examples of interactive exercises created in the LearningApps environment.

grade, in the study of a particular topic. Ready projects can be stored on a local storage or network. In figure 17 some examples of interactive exercises developed by our students are shown.

The designer of education games “Studystack” (http://www.studystack.com/) allows not only to create interactive exercises using the set of templates, but also offers practical tasks already available from a variety of subjects: Mathematics, ICT, Nature, Art, History, etc. Projects are stored on the server, which allows to use them both at the school and as home training. The designer has been working since 2001 and has accumulated a significant amount of ready interactive exercises for children from preschool to high school. The advantage of using this designer is ease of preparation of training exercises: a teacher-to-be simply enters tasks text and correct answers, on which base different versions of interactive exercises are created automatically such as quizzes, crosswords, hit on target games and hangman games, etc.

To create e-simulators a teacher-to-be can also use an environment “GeoGebra” (http://www.geogebra.org). It is very popular nowadays (Drushlyak et al., 2020; Kramarenko et al., 2020). Some examples of e-simulators developed by our students for young learners on GeoGebra are shown in figures 18, 19.

All e-simulators were developed by teachers-to-be for primary school during their studies at H. S. Skovoroda Kharkiv National Pedagogical University. E-simulators in figures are original and tested by the students during teaching practice. They are always available for primary school teachers. We think that the experience for the development of these e-simulators will be useful for teachers-to-be, and teachers in their professional activities.

3 DISCUSSION

The main results of effectiveness of e-simulators are confirmed by many scholars, namely:

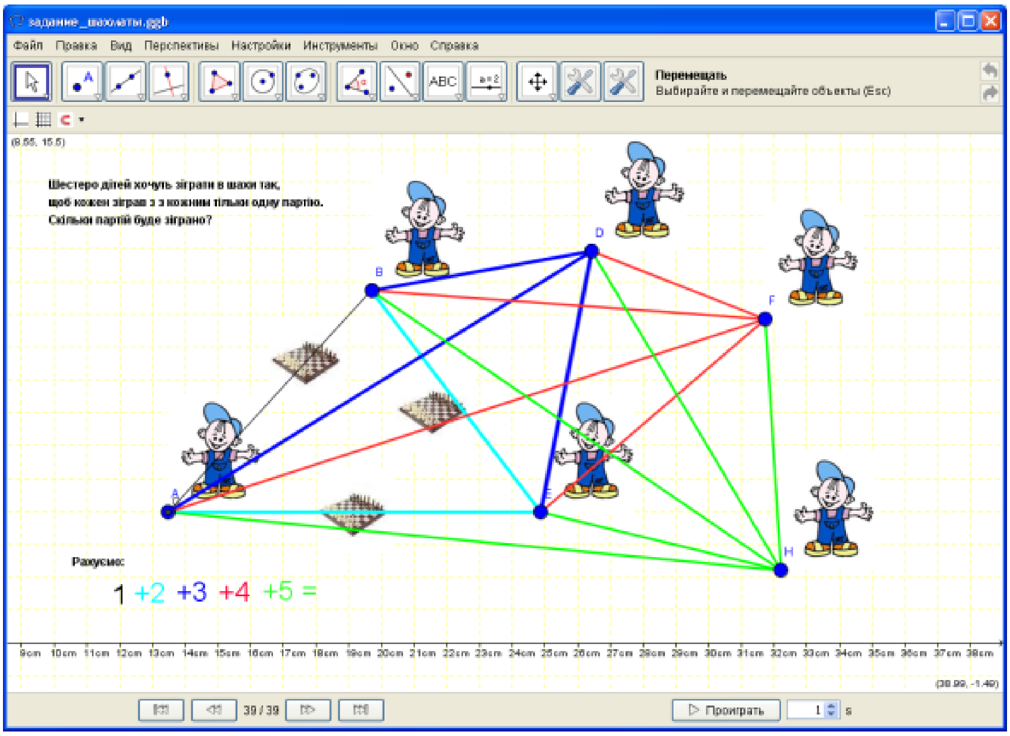

Figure 18: E-simulator for task about chess: Six children want to play chess, so that everyone plays with each player once. Find how many parties will be played?

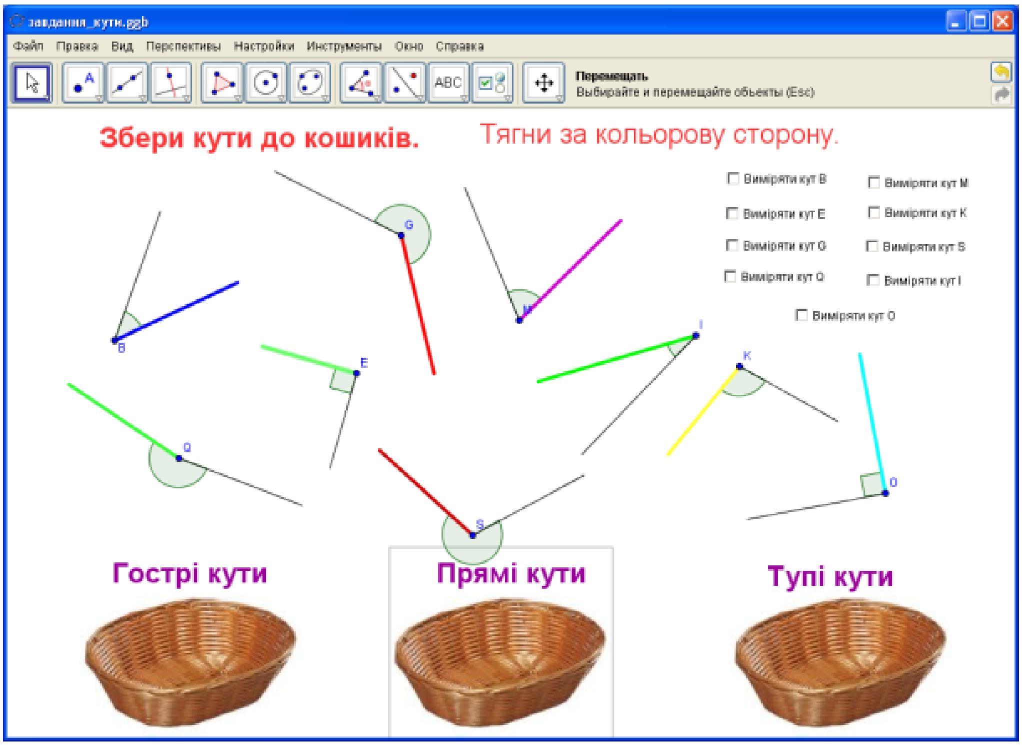

Figure 19: E-simulators for tasks about angles. Children collect right, obtuse and acute angles into baskets.

- instead of being knowledge-focused, e-simulators are built around the skills (Alayyar et al., 2012) necessary to carry out specified tasks in primary school; the focus is on what young learners can do at lessons rather than on what they know;
- young learners are expected to demonstrate practice-added skills which are assessed by looking at outcomes of e-simulators rather than process (www.curriculumonline.ie, 2001);
- young learners' performance is evaluated during the instructional process against common learning standards (Alayyar et al., 2012; www.curriculumonline.ie, 2001), and all forms of assessment are standards-based and criterion-referenced (Hughes and Daniels, 2013). After all, teachers-to-be will be able to deliberately choose the most effective direction in learning young learners with e-simulators.

4 CONCLUSIONS

Use of e-simulators is an effective way of developing successful general study skills for young learners. E-simulators feature the ability to provide real variability of tasks, uniqueness of exercises, operative assessment of correctness in each task, adjustment of task difficulty, ability to provide a shade of competitiveness and game to the exercises. E-simulators can be created by the universal software tools, such programs that are part of an integrated Microsoft Office package or special designing environments.

The capabilities of the e-simulators are covered, which ensure successful acquisition of knowledge, for developing young schoolchildren's skills. Considered tool kits enable a teacher-to-be to design independently author's e-simulators that meet the needs of a particular lesson, enable to achieve the lesson goal with the peculiarities of the educational process at primary school.

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Information and Communication Technologies in Application, Dissemination and Evaluation of Erasmus+ Jean Monnet Activities

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Keywords: Erasmus+ Jean Monnet Project, Information and Communication Technologies (ICT), Food Safety Competence, Evaluation, Education.

Abstract: A new training module on EU Food Safety Control was developed and implemented at the Department of Veterinary and Sanitary Examination (currently Department of Veterinary Hygiene) of NULES. The article describes ICT used for the achievements of results of Erasmus+ Jean Monnet Module “EU Food Safety Control”. Module in the EU food safety control was design to contribute to better understanding of applied system of European food safety assurance and the objectives of official food control at EU level within the frameworks of different types of competencies. To assess the effect of the educational course on food safety control, at the start and after completion of the Module, participants’ knowledge were evaluated. The monitoring of the project results presents a comparative analysis of the implementation strategy for blended learning stage (before spring 2020) and distance learning under the COVID-19 disruption. Tools and the degree of involvement and satisfaction of participants in the project outputs were determined. Impact effort matrix technique reviled that action taken with ICT are the best for achieving project result.

1 INTRODUCTION

Making better use of digital technology for teaching and learning is one of three European Digital Education Action Plan priorities (ec.europa.eu, 2021; eur-lex.europa.eu, 2018). The strategy for the development of education in the European Union and other countries for the last decades has been focused on the introduction of information and communication technologies (ICT) (eur-lex.europa.eu, 2018; Osorio and Nieves, 2014; Khvilon and Patru, 2002; Cranmer, 2014). Currently education systems are increasingly embedding digital competencies in their curricula (European Commission/EACEA/Eurydice, 2019; Moiseienko et al., 2020). These trends became more relevant with regard to the COVID-19 disruption when most educational institutions were forced to discontinue or transform the educational process (Miao et al., 2020; Di Pietro et al., 2020). Those universities win that had the basis, skills and experience to work with various ICT tools and digital environments (Morze et al., 2013; Lynch, M., 2018; Vlasenko et al., 2020).

In addition to the pandemic impact strategic integration of Ukraine into the European Community is one of priority of development, determined by its close geographic location and interaction in trade, first of all by agricultural produce (Galaburda and Yakubchak, 2019). The appropriate level of education, relevance and competence of educational programs to the request of society determine the future in the internal and external labor market. The interdisciplinary nature of food safety assurance demands complex knowledge of future food safety experts (Kholoshyn et al., 2020). Serious gaps in training curricula of the future veterinarians and poor awareness of the food safety concept and the key aspects of the EU official food safety control in Ukraine was the key reason of development of Jean Monnet Module “EU Food Safety Control”.

As any educational and project activity Erasmus+ Jean Monnet Module need to be monitored (ec.europa.eu, 2020) and its success is evaluated by significant results (DG EAC, 2020; Mariott and Goyder, 2009).

Objectives of the research was to assess outcomes

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of the project and value the role of ICT in achieving the project results: the effect of teaching activities, dissemination effect of open events, and overall assessment of relevant project outputs by action priority matrix, judged on the basis of strategy for the dissemination and exploitation of project results for Jean Monnet projects.

2 THEORETICAL BACKGROUND

Erasmus+ Jean Monnet Activities are one of European grant supported programs intended to promote the benefits of European integration and development of cooperation, dissemination of European studies in Europe and other continents. The initiative of the grant conditions of the program belongs to the Council of European Universities and teachers from all over the world who conduct research in the field of European integration (Lynch, M., 2018). Grant funds are earmarked and allocated to universities to start in the educational process of teaching disciplines that are directly related to the development of European law, European economy, education, science, culture, history, theory and practice of European integration. The content of the Jean Monnet European Education Module under the terms of the grant project was to develop and teach specially designed short-term courses on European integration for a certain category of students. Figure 1 describes how the general objectives of the Jean Monnet Erasmus+ Programme are addressed in the module activities and ICT integration in the project "EU Food Safety Control" (587548-EPP-1-2017-1-EN-EPPJMO-MODULE).

A new training module on EU Food Safety Control was developed and implemented at the Department of Veterinary and Sanitary Examination (currently Department of Veterinary Hygiene) of National University of Life and Environmental Sciences of Ukraine (NULES). The course addressed key elements of European food law, including the EU's strategy for food and feed safety assurance and the processes of food safety policy integration. The module include fundamental questions – theoretical background of food safety based on risk analyses and practical application of procedures for official controls in the food processing chain.

There were three cohorts of participants:

1) students of the fifth term of the Faculty of Veterinary Medicine with similar educational background;
2) participants of the open events;
3) principal participants of the project (authors of the project and other experts involved in project management).

Main research questions of the study aimed:

1. To assess the effect of ICT introduction in the "EU Food Safety Control" module on knowledge and skills development of the students.
2. To assess dissemination effect and impact the ICT make to the open event success.
3. Value the ICT role in achieving project results from the point of management and implementation.

3 STUDY DESIGN

3.1 Target Groups, Activities and ICT Involvement

The main target group of the module educational activities (first cohort) was Master's students of the Faculty of Veterinary Medicine studied the training course "EU Food Safety Control" (figure 2).

For evaluation of university course efficiency and the role of ICT in teaching activities, data of the students testing were analyzed as a general cohort and with regard to different conditions of the course delivery. For that purpose participants were divided in three groups: 1-st group studied the course as blended learning (with both contact lectures and seminars supported by the course on e-learning platform); 2-nd group studied the course with both lectures and seminars delivered with Zoom and supported by the e-learning course; 3-rd one had only Zoom lectures but seminars were provided only with e-learning platform.

Open activities, like summer school and round tables, were targeted to students and participants from outside the department meaning that, all interested stakeholders who specialize in related issues were invited to take part in. That was the second cohort of involved participants, that included students and researchers, practicing veterinarians, representatives of the State Service of Food Safety and Consumer Protection (SSFSCP), NGOs and other EU projects in Ukraine.

Principal participants responsible for the project management and implementation (third cohort of participants) were involved in assessment of project management efficiency by the project outcome.

The readiness for the introduction of digital technologies in the educational process and project activities was studied in NULES of Ukraine for designing

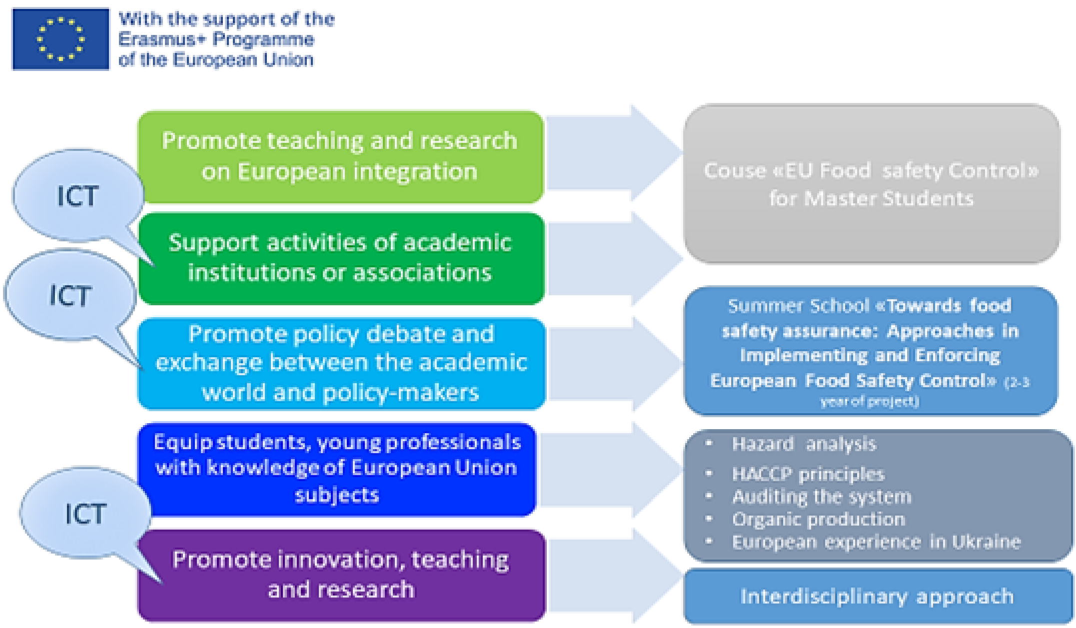

Figure 1: Consistency between programme objectives and design of Jean Monnet Module “EU Food Safety Control”.

the project implementation plan with the maximum involvement of digital technologies (Kuzminska et al., 2019). As a result, the digital educational environment of NULES of Ukraine (https://nubip.edu.ua/en/node/3033) has the necessary resources for the effective implementation of the project.

The preparation stage comprised of developing the content of the web page to be hosted within the university website (https://nubip.edu.ua/node/72229) and FoodSaCo site development (http://greeneconomy.com.ua).

An e-learning training course “EU Food safety Control” (erasmusplus.org.ua, 2020) covers the actual issues of organization of food safety assurance system of the European Union and its legislation on the food safety. The course was developed by the FoodSaCo team and became one of the modules of the courses “State Veterinary and Sanitary Control” for Master’s students in Veterinary Hygiene, Sanitary and Expertise (VHSE), “State Veterinary and Sanitary Expertise” for Master’s students in Veterinary Medicine (VM), and university elective course “EU Food Safety Control”. According to the plan, the project educational activities, started in September 2017, included delivery of the educational course to the Master Students of Veterinary Hygiene, Sanitary and Expertise and Veterinary Medicine.

The Summer Schools “Towards food safety assurance: Approaches in Implementing and Enforcing European Food Safety Control” with round table debate “EU – Ukraine interaction for the food safety assurance” was planed for the second (2019) and third (2020) year of the project as open event for Ukrainian competent authorities and food business operators, State Service of Ukraine for Food Safety and Consumer Protection (SSFSCP) inspectors, practical veterinarians, higher school lecturers and researchers, the public in order to disseminate project results.

First Summer Schools with round table debates implemented one on May 14–16, 2019 on the basis of the state institution Scientific and Methodological Center for Information and Analytical Support of Higher Education Institutions “Agroosvita” with 50 registered participants, involving teachers of vocational education institutions, representatives of the SSFSCP, NGOs and other EU projects in Ukraine.

Taking into account special measures at the national and University level caused by COVID-19 outbreak, open school 2020 was implemented via Cisco (Webex Event) platform and resulted in better dissemination due to attraction more than 180 participants.

Digital resources that were used in project implementation could be divided in following categories (Assar, 2015):

1. Didactic components used to support learning inside the course and project events.
2. Communication tools (emailing, messaging, web conferencing).

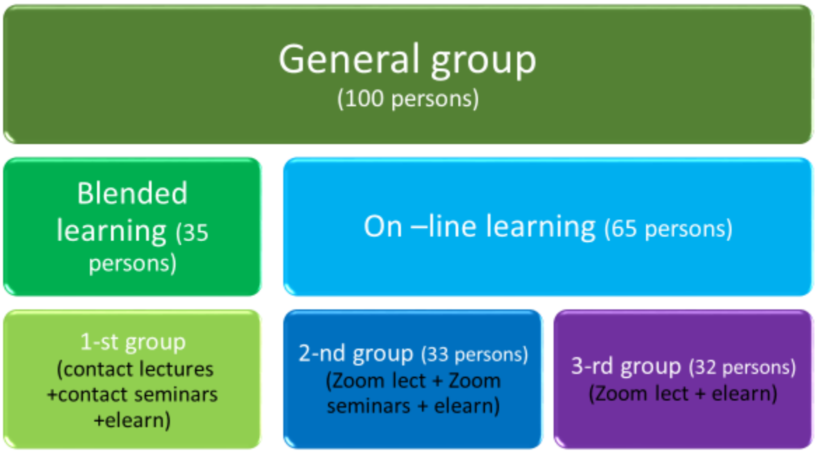

Figure 2: Organization of the educational process and different conditions of the course delivery.

3. Learning Management System (on-line course delivery).

Two first years of the project implementation involved digital and ICT tools only as didactic and supportive. The e-learning course was developed in accordance with the "Regulations on Organization of Academic Process in NULES" and was not declared in approved project application. Due to presence and sufficient development of university digital learning environment (DLEs) our project continued to implement the program of action with certain flexibility despite special measures taken at the national and the university level caused by COVID-19 outbreak. The teaching activities for MSc students in spring 2020 were delivered on-line with Zoom lectures but seminars were delivered only by the distant learning course on the university e-learning platform (erasmusplus.org.ua, 2020). Students of Veterinary Medicine in 2019 had blended learning (contact lectures and seminars supported by the course on e-learning platform), and in autumn 2020 studied on-line with both lectures and seminars provided in Zoom, with the support of the university e-learning platform.

Previously planned Spring school 2020 "Towards food safety assurance: Approaches in Implementing and Enforcing European Food safety control" was implemented in Cisco (Webex Event) platform and resulted in better dissemination due to attraction more than 180 participants.

3.2 Methods and Study Materials

To discover the first research question students' knowledge on food safety control was assessed prior to the delivery of the educational Module curriculum using a pretest that included true/false and multiple-choice questions. The participants completed the same food safety control knowledge assessments (posttest) immediately after course completion via an online test on the university e-learn platform (erasmusplus.org.ua, 2020). The homogeneity of entry tests results were the basic to consider the groups as homogenous. Collected data were initially summarized in Microsoft Excel and analyzed with Students' t-distribution.

The second research question dealt with the second cohort of participants. Open event held online (in 2020) resulted in involvement of 30 students and 150 researchers, representatives of the SSFSCP, NGOs and other EU projects in Ukraine – 180 persons total. For open summer school activity a short questioner was developed on the attitude and impression about distance learning activities and events (http://surl.li/pqyf). The participants were asked about general impressions of the event, their attitude to events (conferences, etc.) held on-line and the effectiveness of that kind of activities. The questions of the study also considered the participants' perception of distance learning vs. full-time, and a) main benefits and b) main disadvantages of distance learning.

Project team (third cohort), including 12 participants in total from the Faculty of Veterinary Medicine, Faculty of Information Technologies, International Relation Office, university financial department and Erasmus+ Office of Ukraine conducted the assessment of ICT for the project management success. Impact effort matrix technique was used for determining the best action taken for achieving project result. The criteria for assessment project results were developed in accordance with Erasmus+ working documents (Bens, 2017; Mind Tools Content Team, 2015). The impact of each project outcomes and effort involved were scored from 0 to 10. By creating a matrix with four quadrants and plotting the results based on the effort required to implement (x-axis) and the impact (y-axis), the outcomes falling into the upper left-hand quadrant are the best action taken.

4 MAIN FINDINGS

4.1 Evaluation of University Course Efficiency

Participants' food safety control knowledge was evaluated with a questionnaire before and after the module. The results of pre- and post-tests are provided in table 1.

The questionnaire included questions about different aspects of food safety assurance. Only 3 out of 100 participants had grades lower than 60% and 9 had minor (i.e. = 60%) food safety knowledge in the pretest. After the delivery of module, students demonstrated certain progress in knowledge. The progress in case of blended learning, when students had contact lectures and seminars additionally supported with e-learning platform (1st group), was considerably higher than in case of on-line study in general, but when lectures and seminars were provided through Zoom (2nd group) students demonstrated the slightly lower post-test results. Nevertheless, the study indicates that Zoom seminars in the condition of on-line study could be considered as effective as contact lessons. Students of 3rd group, who did not have Zoom seminars, demonstrated the minimal progress, although they had the highest pretest results. The latter corresponds with findings of Mok et al. (Mok et al., 2015) that the students with lower initial grade improves at a faster rate than those who started at a higher level.

4.2 Open School Activities Application and Evaluation

The main purpose of open events were to disseminate the results of the project by sharing practices, knowledge and experience gained during the project. Comparison of the number of participants and organizations involved in contact and on-line open event indicated the better dissemination effect of the on-line meeting.

Participants of on-line event were offered to take part in survey about their impression and attitude to the event and to distance learning (http://surl.li/pqyf). All participants had good impression about the event emphasizing on high quality of organization and content. About the efficiency of on-line events (conferences, etc.): 64.5% of respondents reacted positively, indicating that it is an opportunity to join the discussion of topical issues and save money and time; 20.7% indicated that the form of communication does not matter if the topic is interesting and experts are experienced; 10.7% of participants considered the on-line communication only in case of force majeure (for example, quarantine); and only 4.1% reacted negative, assuming the face-to-face events are more effective.

The idea of distance learning was clearly supported by 9.9% of respondents; 36.4% preferred blended learning; 38.8% considered that the form of learning is not essential if a person is motivated to learn; 10.7% believe face-to-face training is always more effective; 4.1% emphasized the need of support from administration.

As main disadvantages of distance learning participants considered technical failures, lack of contact with audience and between participants.

4.3 Project Results Impact vs Effort Evaluation

The evaluation of taken efficiency actions for achieving project outputs or outcomes that are relevant for project results (ec.europa.eu, 2020) reviled that most effective of them involve ICT (marked blue) (figure 3).

Most of the activities with ICT technologies required certain effort or better preparedness and skills from the team involved in project implementation.

5 CONCLUSIONS

The specific targeted impacts of the project was teaching and dissemination the key aspects of the EU food safety assurance system, contributing to reflection and debate about food safety official control challenges of Ukraine.

Methodical support of the teaching activities was provided through presentation of all teaching materials, including lectures and reports on eLearning portal of the NULES and project website.

The findings clearly demonstrate the importance of ICT in successful implementation of project results. Developed EU food safety official control

Table 1: Analysis of the success rate of training participants by method of communication during educational process.

Group of students	Pre-assessment test rate	Final test rate	Progress rate	Progress %
General cohort % to maximum grade	21.31±0.47 71.04±1.55	24.65±0.44 82.15±1.47	3.33 11.11	15.64
1st (contact lectures and seminars + LMS Moodle courses) % to maximum	21.38±1.13 71.28±3.03	28.65±0.47 89.49±1.39	5.46 18.21	25.54
On-line (general) % to maximum grade	20.83±0.52 69.44±1.73	23.93±0.55 79.78±1.90	3.10 10.33	14.88
2nd (Zoom lectures and seminars + LMS Moodle courses) % to maximum grade	20.12±0.37 67.06±1.46	24.88±0.64 82.94±2.13	4.76 15.88	23.68
3rd (Zoom lectures + LMS Moodle courses) % to maximum grade	21.77±0.77 72.56±2.55	22.69±0.74 75.64±2.47	0.92 3.08	4.24

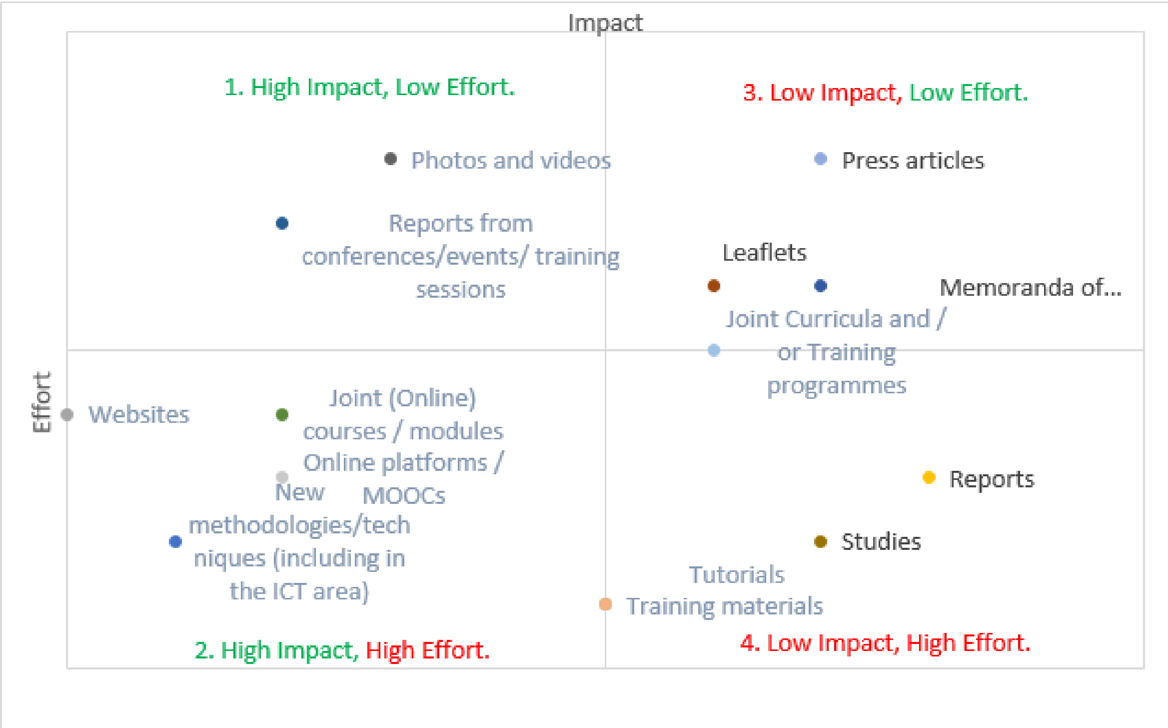

Figure 3: Impact effort matrix of project result.

course at NULES LMS Moodle platform and introduction open events via WebexEvent platform, despite the COVID-19 disruption, realized a broad outreach to the student community by ensuring the participation of all interested stakeholders (i.e. not just students from the Veterinary Medicine Faculty) as well as participants from other universities, organizations and projects in Ukraine, who are and going to be involved in food safety assurance.

Blended learning, when students had contact lectures and seminars additionally supported with e-learning platform demonstrated better progress than in case of on-line study.

Impact effort matrix technique reviled that action taken with ICT were the best for achieving project result.

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Using the LearningApps.org Online Service in the Moodle System in the Process of Training of Specialists in Economic Specialties

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Keywords: Interactive Tasks, Distance Learning, Moodle, LearningApps.org Online Service, Competencies.

Abstract: The article deals with the peculiarities of using LearningApps.org online service in the Moodle system in the process of training of specialists in economic specialties. Methodology of integrating interactive tasks in economic disciplines of LearningApps.org online service into the Moodle learning management system has been considered. Practical aspects of using interactive tasks while teaching professionally oriented educational disciplines by education applicants of economic specialties have been reflected. The didactic component of the Moodle system in the process of realization of distance and mixed learning in the pandemic period and formation of future specialists' professional, informational and communicative competencies, development of their creative thinking has been revealed in the process of research activities.

1 INTRODUCTION

Accession of Ukraine into the world informational and educational community requires training of skillful specialists in economic specialties, able to respond flexibly to labor market conditions. Nowadays, one of the priorities of the system of professional pre-higher and higher education is training of competitive specialist, who has got a high level of professional competence. Innovative processes in educational system need some new studying strategies, which would correspond to the world tendencies of creation of global markets, formation of a new information society and transformation of knowledge into direct productive force (Boliubash, 2012).

Sarkar (Sarkar, 2012) believed that the use of ICT in education can increase access to learning opportunities. It can help to enhance the quality of education with advanced teaching methods, improve learning outcomes and enable reform or better management of education systems. The continued use and development of ICTs within education will have a strong impact on: What is learned, how it is learned, when and where learning takes place, & who is learning and who is teaching. The continued and increased use of ICTs in education in years to come, will serve to increase the temporal and geographical opportunities that are currently experienced. The integration of ICTs in higher education is inevitable (Sarkar, 2012).

The importance of didactic component of modern information technologies in the process of training of specialists in economic specialties is that they can be used both during training for transferring knowledge and for providing feedback between higher education applicants and scientific and teaching staff. In the process of using information technologies, the skills of independent work, which plays an important role in the formation of the future highly qualified competitive economic specialist, are developed and predominated in higher education applicants. Since in mod-

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ern conditions of rapid development of science, quick information updating it is impossible to provide the higher education applicant with a knowledge base that will be relevant throughout life – it is important to develop his interest in the accumulation of knowledge, to continuous self-education. The task of the institution of higher education is to train future specialist, ready for regular professional growth, social and professional mobility, capable of self-regulation in the field of continuous education (Kinash, 2011). One of the main problems of introducing innovative forms of education is the choice of the optimal ratio of the best traditions of the existing educational system, modern pedagogical innovations and tools of information and communication technologies (Semerikov et al., 2021; Isaikina and Zlenko, 2021).

The relevance and possibilities of using information technologies in the educational process have covered in (Bonk and Lee, 2017; Boichuk et al., 2019; Bykov et al., 2001; Gergei and Mashbits, 1986; Gryniova et al., 2019; Kononets, 2015; Lavrentieva et al., 2021; Markova et al., 2015; Morze et al., 2017; Osadchyi and Osadcha, 2015; Poyasok et al., 2020; Ramsky and Rezina, 2005; Semerikov et al., 2018; Spivakovsky et al., 2013; Trius et al., 2004); the use of ICT in the training of future economists was described in (Boliubash, 2012; Kostenko et al., 2018); Bilousova et al. (Bilousova et al., 2013), Bulakh and Mrouga (Bulakh and Mrouga, 2007) explored the theory and methods of computer testing higher education applicant's achievements.

The researches (Bobyliev and Vihrova, 2021; O'Reilly, 2012; Patarakin, 2002; Vlasenko et al., 2020; Zhaldak et al., 2021) are devoted to the problem of using Internet, Web 2.0 technologies and online services in education.

The use of Internet and dependency on digital gadgets has transformed the learning and knowledge sharing approaches (Sarkar, 2012; Arkorful and Abaidoo, 2015). ICT has not only revolutionized and transformed the classroom learning and teaching methods, but also mutated distance learning programs, leading to reshaped libraries as well as accessibility towards learning materials (Farid et al., 2015). Thus, persistent up gradation of technology aided the access to the digital world of information (Soomro et al., 2018).

Theoretical and methodological principles of distance learning technology have been substantiated in (Boliubash, 2012; Franchuk and Prydacha, 2021; Kukharenko and Oleinik, 2019; Petrenko et al., 2020; Polhun et al., 2021; Vakaliuk et al., 2021).

Despite the considerable attention of scientists to the study of innovative learning technologies, the organizational and methodical aspects of study to create a modern educational information environment that meets the educational information needs, insufficiently studied. The mechanisms for the introduction of fundamentally new forms and methods of studying, based on the Moodle distance learning system, which is a leader among educational systems of a new type – Learning Management Systems (LMS), need further development (Boliubash, 2012).

2 METHODS

The following empirical and theoretical methods of research were used in the process of study: analysis of scientific works on using information technologies in the process of training of specialists in economic specialties, in particular, the LearningApps.org online service and the Moodle learning management system; synthesis of ideas for the use of interactive tasks in the teaching of economic disciplines; observation of higher education applicants in the process of studying economic disciplines; generalization of advanced national and foreign experience in the use of interactive tasks of the LearningApps.org online service in the Moodle system; statistic method – allowed to make a conclusion about the effectiveness of interactive study in the Moodle system.

Study of features of using the LearningApps.org online service in the Moodle system in the process of training of specialists in economic specialties proceeded in the Separated Structural Subdivision (SSS) "Berezhany Professional College of NULES of Ukraine". The higher education applicants of economic specialties became the participants of the pedagogical research.

3 RELATED WORK

Enhancing and upgrading the quality of education and instruction is a vital concern, predominantly at the time of the spreading out and development of education. ICTs can improve the quality of education in a number of ways: by augmenting student enthusiasm and commitment, by making possible the acquirement of fundamental skills and by improving teacher training. ICTs are also tools which enable and bring about transformation which, when used properly, can encourage the shift an environment which is student centered (Sarkar, 2012).

The development of information society involves the widespread use of information technologies in the process of training of future specialists of economic specialties that is determined by the number of factors (Kinash, 2011):

- introduction of information technologies into economic education significantly accelerates the transfer of knowledge and accumulated technological and social experience of humanity not only from generation to generation, but also from one person to another;
- modern information technologies, improving the quality of economic education and study, allow the specialist to adapt to the environment and social changes, which occurs, much faster. This gives an opportunity to each person to get necessary knowledge both today and in the future;
- active and effective introduction of these technologies into economic education is an important factor of creating education system that meets the requirements of modern information society and the process of transformation of traditional education system into a new system.

The process of introduction and the further use of various components of educational information environment is based on a number of principles, in particular: resource availability, systemic, adaptability, interactivity, practical orientation, security, transparency, efficiency and mobility. This process contributes to the formation and development of intellectual potential of higher education applicants, improving the forms and content of the educational process, introducing computer methods of study that gives the possibility to choose problems of specialists' training at a better level, taking into account international requirements. The improvement of educational process management, individualization of study, improving the quality of education at all levels of specialists' training, organization of systematic control of knowledge, integration of educational, research and practical activities, the ability to take into account psychophysiological features of each higher education applicant and research and teaching staff, etc., is the result of such implementation (Petrovych and Rymar, 2012). Cox (Cox, 2020) believes there will be an increase in concepts that have been around, such as Massive Open Online Courses (MOOCs), or textbooks that are free to access.

The special tools for distance learning – Course Management Systems (CMS), also known as Learning Management Systems (LMS) or Virtual Learning Environments (VLE) are used to conduct this type of training. Such systems are designed to store training materials, automatic testing for higher education applicants, their distance communication, storing information about them and their achievements, keeping reports on the work of distance learning subjects (Osadcha and Osadchyi, 2013).

Using LMS in the learning process helps facilitate e-learning as it provides educational material without the constraint of time or place (Ain et al., 2016), enabling students and teachers to interact via the internet and facilitates sharing of course-related information and resources (Lonn et al., 2011). A few examples of LMS used in educational institutions include Moodle, WebCT, Blackboard, and Desire2Learn (Waheed et al., 2016). Hassanzadeh et al. (Hassanzadeh et al., 2012a) revealed in his study that, with the advent of information technology, the definition of higher education had been changed. In recent times, the acceptance of e-learning systems and technologies is being investigated by researchers in different educational environments around the world, using different models based on distinct criteria (Hassanzadeh et al., 2012b; Khan and Rafi, 2020; Raza et al., 2021). It is worth to mention that Moodle is the most popular Course Management System, as evidenced by both the results of Google Trends statistics and data from the ListEdTech.com resource (Osadcha and Osadchyi, 2013).

The heart of Moodle is courses that contain activities and resources. There are about 20 different types of activities available (forums, glossaries, wikis, assignments, quizzes, choices (polls), SCORM players, databases etc) and each can be customised quite a lot. The main power of this activity-based model comes in combining the activities into sequences and groups, which can help you guide participants through learning paths. Thus, each activity can build on the outcomes of previous ones. There is a number of other tools that make it easier to build communities of education applicants, including blogs, messaging, participant lists etc, as well as useful tools like grading, reports, integration with other systems and so on (Moodle, 2021).

As an example of a successful combination, we consider the LearningApps.org online service – free Web 2.0 service, which contains exercise blocks of general use and allows creating tests, prepare training exercises for fixing the material and further use in educational process. This resource supports the developments and contains a bank of exercises in 20 languages, including Ukrainian, English, German, Russian, Bulgarian, Romanian, Polish and others. It should be mentioned that LearningApps.org information is not translated into all languages, but is filled by its users (Korniienko and Fedchenko, 2016). The proposed by this service set of tools is interesting because it allows you to control the achievement of cognitive goals not only at lower levels of Bloom's taxonomy (remembering, awareness, application), but also higher (analysis and evaluation). All exercises are evaluated. Some of them have an input rating scale (for example, Quizzes), for most other types mark has the character of enrollment, and the exercise is performed until the correct answer is found (Bihun, 2018). Note that this service is one of the most functional and convenient; higher education applicants easily can independently study the functionality of the service and create interactive tasks.

The LearningApps.org can be used for creating various interactive visual exercises in games, competitions, classes. There are the following types of interactive exercises in the LearningApps. org system: category Choice (Quiz, Multiple-Choice Quiz, Highlight the words, The Miilionaire Game, Words from letters); category Distribution (Pairing Game, Group assignment, Matching Pairs, Puzzle "Vpiznaiko (Recognizer)", Sorting, Correlation) and others. Important helpful function of this resource is possibility to look through the tasks of other users, as, for example, for creating own interactive exercise. After creating some task, you will be able to publish, download, or share it with other users (Pavlenko, 2016).

Sablina (Sablina, 2017) reports that the LearningApps.org service is a Web 2.0 service to support processes of learning and teaching with a help of not big interactive modules. These modules can be used directly as learning resources or for independent work and for self-assessment of education applicants. Interactive educational environment of the LearningApps.org proposes some interactive exercises divided into the following categories: by subject, by level of education degree and ready-made templates that you can use or create your own. Creation of tasks in the LearningApps.org environment is performed on the basis of the proposed templates.

Stechkevych and Stechkevych (Stechkevych and Stechkevych, 2020) mention that didactic materials created by means of this service perfectly fit into the program of competitions, quizzes and other extracurricular activities. The benefit of these resources is possibility for teacher to create his/her own repository exercises, add interactive elements into educational process, and at the same time to raise the level of interest of education applicants, which is relevant in the conditions of distance learning.

Taran (Taran, 2014) determined that education applicants with the help of templates of the LearningApps.org service create both practical and control parts of the educational module that allows to examine the level of formation of special abilities of education applicants of different ages.

LearningApps.org – designer of interactive tasks, which allows you to conveniently and easily create electronic interactive exercises, which promotes activity, independence, efficiency, connection of theory with practice, a combination of collective and individual forms of educational work and more (Isaikina and Zlenko, 2021).

Using modern information technologies, including interactive learning technologies, opens wide prospects of deepening theoretical base of knowledge, strengthens motivational orientation to studying of disciplines, provides mastering of skills of person's self-development, an opportunity to think, create (Sablina, 2017).

The process of technologicalization of education is certainly accompanied by the involvement of students in mastering the methods of using the capabilities of information computer technologies (Boichuk et al., 2019). A number of researchers have already begun to propose various tools, techniques and approaches to support the active involvement of both teachers and students in the design of learning tasks and environments; new instructional and learning design practices are emerging that are based on the idea of student ownership of tasks, and that emphasise the importance of allowing flexibility, encouraging self direction and choice as well as promoting creativity in the performance of tasks (McLoughlin and Lee, 2010).

Results of the conducted research of using interactive tasks in the educational process indicate the intensification of the educational process and the intensification of cognitive activity of higher education applicants (Osadchyi and Osadcha, 2015).

The last period is characterized by active process of implementation of distance education into national learning environment. Higher education institutions intensify activities and develop various electronic educational resources (manuals, textbooks, virtual workshops, repositories, web-based learning support systems, distance learning courses, etc.), study possible ways of organization of distance classes, presentation of educational material, solve issues of technical support of online learning, study other theoretical and practical problems, related to the introduction of distance learning in Ukraine. Educators used previously electronic learning resources only as teaching aids, in today's reality e-learning resources are the only way to ensure the educational process by improving its quality due to the high degree of visualization of learning material and accessibility, individualization, interactivity, self-control in study. The system of e-learning resources, which can be proposed by instructors and institutions of higher education, is a powerful didactic resource for providing a system of support for distance education as a requirement of the time (Gryniova et al., 2019).

The instructors of SSS "Berezhany Professional College of NULES of Ukraine" place all electronic educational and methodical complexes on the portal of distance and blended learning Moodle (http://www.nipba.tk/). In such way the higher education applicants have opportunity, after identification, get access to distance learning courses at any time convenient for them. Also there are electronic manuals, tutorials, workshops, multimedia presentations, etc. on the portal to provide a system of support for distance and mixed learning.

Given the situation in connection with COVID-19, the distance and mixed learning portal Moodle is used actively now and, accordingly, helps to form professional competencies, information culture of future economic specialists, professional self-awareness, to realize the creative potential in higher education applicants.

4 RESULTS

Introduction of interactive study by means of the LearningApps.org online service in the Moodle system into educational process took place on the basis of SSS "Berezhany Professional College of NULES of Ukraine". The developed interactive tasks with the help of the LearningApps. org online service on disciplines of "Banking operations", "Insurance services", "Economic analysis" were used during the classes with higher education applicants of economic specialties.

Introducing the traditional professional training of network technologies on the basis of Moodle system in the educational process of future specialists in economic specialties is accompanied by creation of the didactic information environment which is a platform for realization of process of training via the Internet, contains educational information and information with results of educational activity. Moodle Learning Management System has wide possibilities for multimodal presentation of educational information, automatization of control and monitoring, performing interactive network communication, parallel actions and exchange of information, using which need making adjustments to the organization of forms and methods of teaching (Boliubash, 2012). Despite the fact that Moodle system is multimodular, but when there is a need to create interactive explanatory-illustrative materials, simulators, questionnaires simply, quickly and attractively, you should use a special separate software tool.

Important aspect of using the Moodle platform in the educational process of future specialists in economic specialties is the ability to use external resources that can be built into the system.

External systems can be integrated easily, to maintain authentication, enrolments and other things, allowing Moodle to react smoothly as data in other systems is modified (Moodle, 2021).

Moodle is widely considered by students as a platform for weekly access, rather than a site they visit daily, and they are more likely to log in on the day of their lectures – they generally see it as a resource location, holding the slides necessary for the week's lectures (Mogaji, 2018).

From the view of practical experience of using means of modern information technologies in the educational process we want to note that interactive tasks, developed with the help of the LearningApps.org online service, activate the activities of higher education applicants and act as a mean of control or self-control in the Moodle system.

The advantage of the LearningApps.org service is that the exercise templates have an attractive design, allow to switch on interface elements (markers of reactions to correct and incorrect answers), which have a positive emotional impact on students. Formation of positive emotions is facilitated by the playful nature of many exercises included in the instruction templates, which allow correcting mistakes. Due to this fact the reason for the negative attitude to learning, as failure to perform tasks is eliminated (Stanislavova, 2018). Using the LearningApps.org service helps higher education applicants better fix the studied theoretical material, increase their activity, motivation and interest, acquire skills of independent and collective search for ways to solve the tasks. For clarity, consider the algorithm for creating an interactive exercise on the LearningApps.org online service.

Note that you do not need to register to create and do exercises. But registration is necessary for students to be able to create groups, monitor performance, and create exercises. We will not detail the registration of a new account, but will focus on creating an interactive exercise "Crossword", which is used to develop new concepts of the topic "Credit granting and repayment operations", in more detail.

We recommend to be acquainted with ready-made exercises before starting work on the online service. To do this, you need to activate the option "View exercises" and select an educational discipline from these categories. Each task can be added to your account page ("My exercises"), and soon will use in the classroom, changing to your own needs or creating a completely different exercise. To create an exercise you need to click the option "Create an exercise" and select the exercise "Crossword".

The next step of creating the exercise "Crossword" is to fill in the form of the template, adding text, images, sound, video, description of task, help, feedback, and finally, activate the "Save exercise" option. After saving, the exercise is displayed on the LearningApps.org online service in the "My exercises" tab for use and, if necessary, editing. The exercise status also can be changed from private into public. When the exercise is ready for use, we can give higher education applicants access to its implementation using the QR-code automatically created by the service, which will provide a quick transition to the exercise or by providing higher education applicants with a link to demonstration of the exercise in normal or full screen mode.

Interactive tasks, developed with the help of the LearningApps.org, can be done both directly on the web site of the online resource and on other web resources, in particular in our case on the portal of distance and mixed learning of SSS "Berezhany Professional College of NULES of Ukraine". It should be mentioned that for correct work with the LearningApps.org online service and to be able to embed tasks on other web resources, you must register and obtain your own account.

To place interactive tasks on the Moodle distance and mixed learning portal, you need to copy the link to the task we created in the LearningApps.org online service (figure 1, item 1) or download the SCORM package to your computer (figure 1, item 2).

Consider one of the ways to place interactive tasks of the LearningApps.org online service in the Moodle system, which was used the most often in the process of teaching economic disciplines, namely: the creation of tasks using the SCORM package.

To integrate the created interactive task into the study course, first of all it is necessary to click the "Edit" button in the Moodle system for the corresponding course in which we plan to insert it. When this option is enabled, the developer has the ability to add and edit resources, which are placed in the electronic course. To add the SCORM package it is necessary choose the option "Add an activity or resource" (figure 2), and from the presented list – the SCORM package (figure 3).

After these steps, a window with detailed settings will appear. We will highlight only a few of the most important, in our opinion, settings. For example, after entering the task name and downloading the SCORM package we recommend:

- to click "Show less…" in the item "Appearance" and change setting "Disable preview mode" into "Yes";
- to select "1 attempt" in the item "Attempts management" – "Number of attempts";
- immediately look through the create task, you need to click "Save and display". If necessary, you can change settings.

These settings help higher education applicants take tasks more seriously and conduct self-control of knowledge and skills.

Note that if you select "Unlimited attempts", "2 attempts" and more in the settings in the "Attempts management" item, then higher education applicants will be able to re-perform the interactive task.

More detailed information on settings of the SCORM package you can view by following the link on the Internet: https://docs.moodle.org/311/en/SCORM_activity.

After saving the settings mentioned above, a message will appear stating the number of allowed attempts to perform the task and score, and using the "Enter" button the finished interactive task will open.

Consider the sequence of execution of one of the most interesting interactive task for future specialists in economic specialties, built into the Moodle system – the "Group-Puzzle". To do this task it is necessary to choose the correct answer (figure 4, item 2) to each category (figure 4, item 1). If the answer is correct, some part of the picture will be shown, but if the answer is incorrect, a message will appear stating the cause of the error and the answer itself will be highlighted in red. If the interactive task would be done correctly, a welcoming message will appear.

The advantage of integration of interactive tasks into the LMS Moodle using the SCORM package is that the scores for their performance are displayed in the score journal in the Moodle system. It is always possible to observe whether the higher education applicant (figure 5, item 1) has completed the task, how much time was spent on its completion and how many attempts were made to complete it (figure 5, item 2). The score (figure 5, item 3) of the future specialist is credited only for the correctly performed task. An important component of ensuring monitoring control of studying activities of higher education applicants is that the score journal (figure 5, item 4) can be downloaded in a convenient format.

In addition to interactive task, mentioned above, we used other tasks of the LearningApps.org online service in training of future specialists in economic specialties, including:

- to fix the basic concepts in economic disciplines we use the task "Cloze text" (figure 6), in which

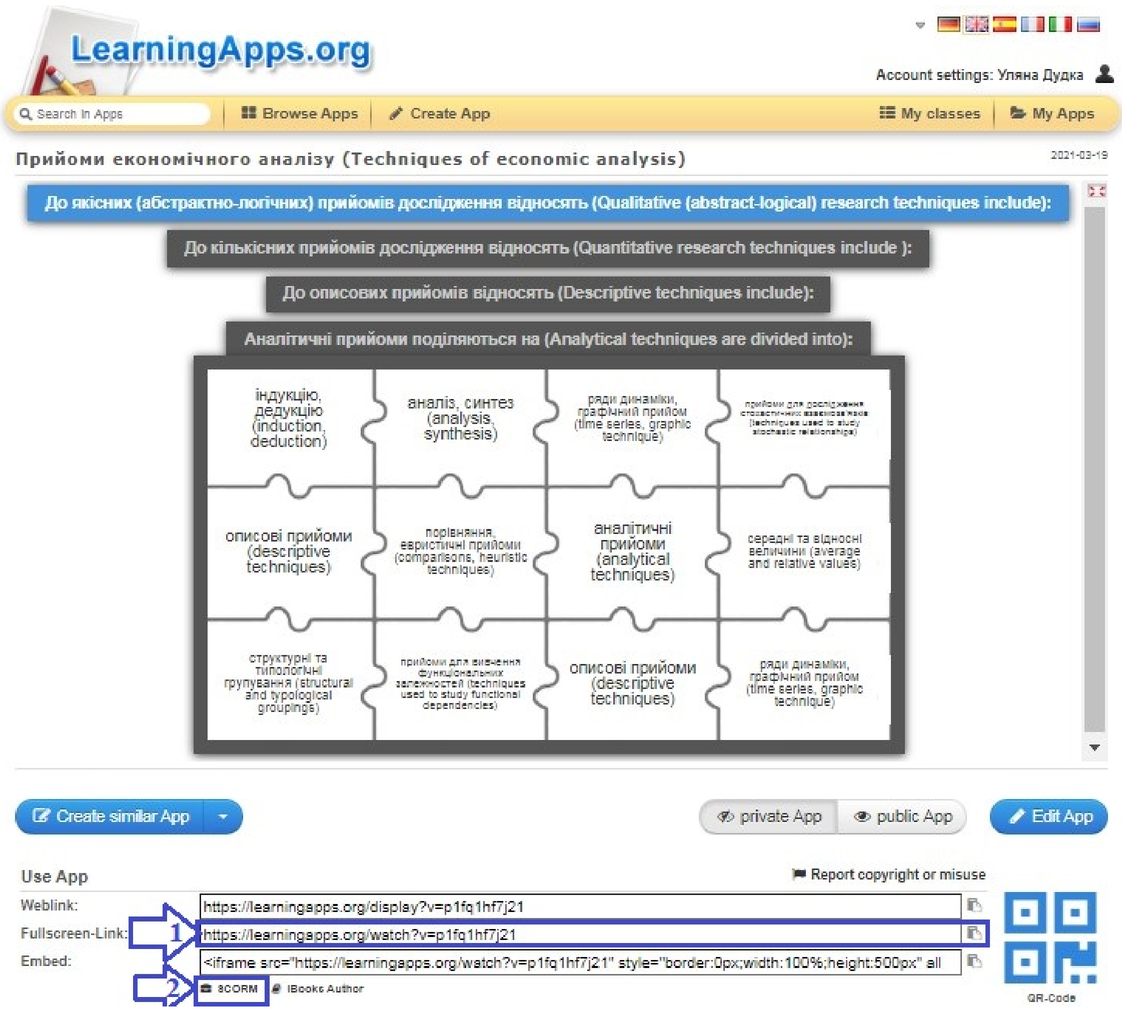

Figure 1: Placing a link or SCORM in the LearningApps.org online service.

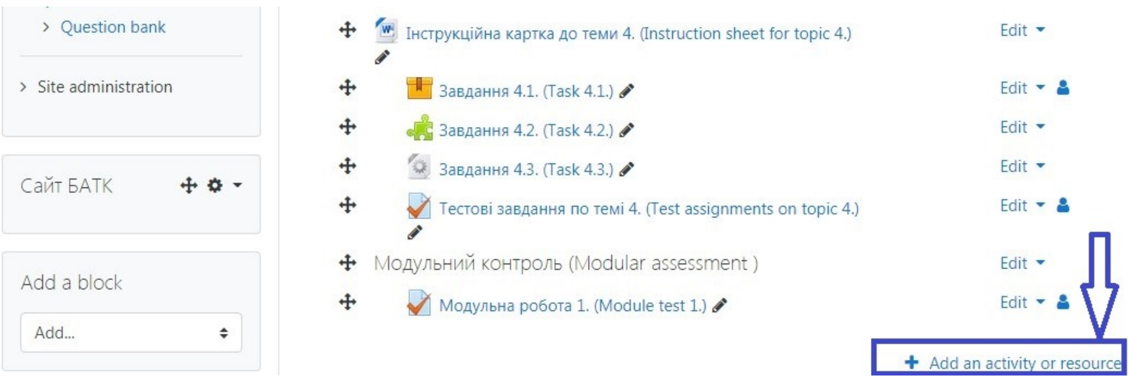

Figure 2: Activation of option “Add an activity or resource”.

you should choose a correct notion from the specified list, and the task “Crossword”, in which it is necessary to fill in some notions to the specified definitions, the task “Freetext input” (figure 7), in which you must enter the missing words or calculated data. Such exercises can be used while studying the topics “Subject and types of economic analysis”, “Methods of factor analysis”, “Methodical techniques of economic analysis”, “Analysis of resource provision of the enterprise

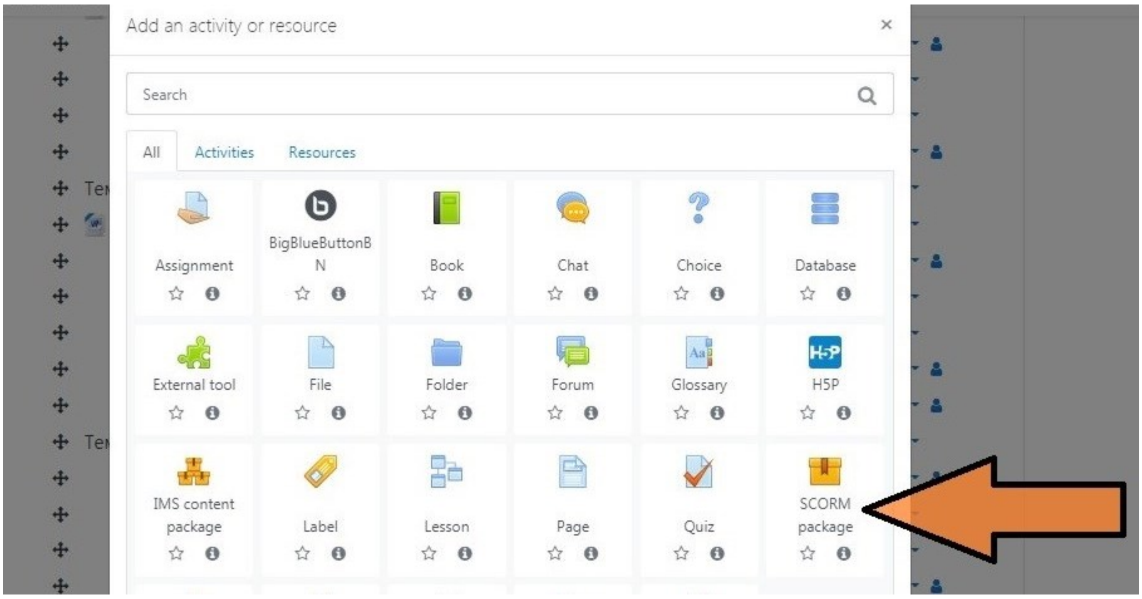

Figure 3: Selection of the "SCORM package".

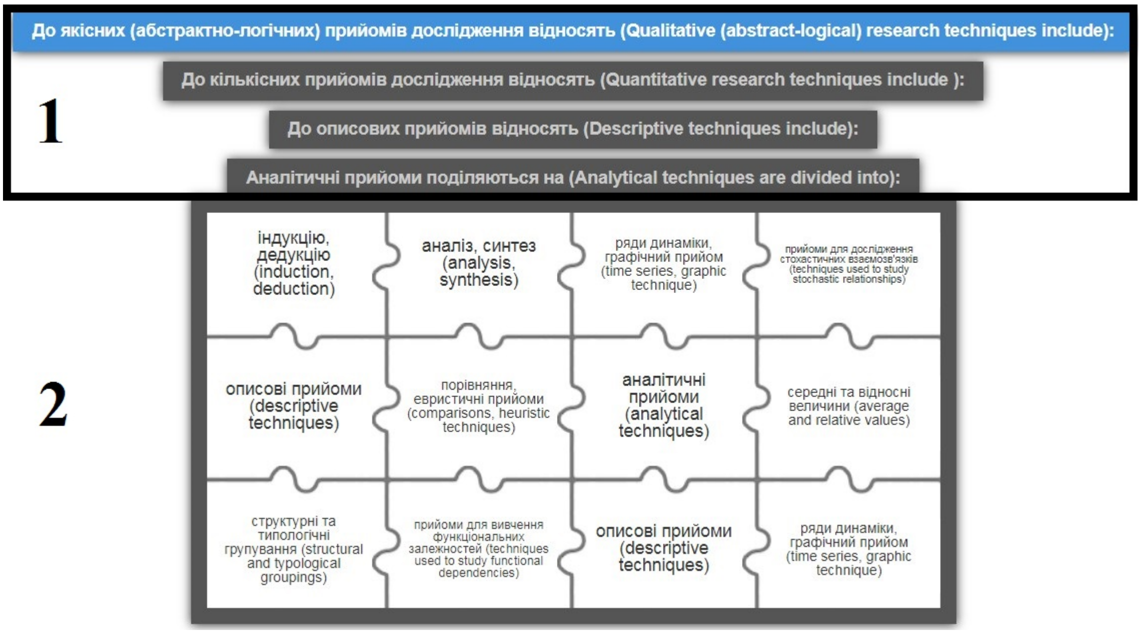

Figure 4: Example of "Group-Puzzle" interactive task.

and evaluation of the efficiency of its resources", "Analysis of production costs", etc.;

- to solve typical questions – the task "Freetext input", in which it is necessary to fill in missing words or calculated data, and the task "Guess", in which you also must enter calculated data or missing words. However, the difference from the previous task is that it is possible to choose an opponent during perming the task. These interactive tasks help future specialists in economic specialties to master such topics as "Analysis of production, works and services", "Analysis of production costs", "Analysis of resource provision of the enterprise and evaluation of the efficiency of its resources", etc.

Thanks to the LearningApps.org online resource future specialists in economic specialties are interested in creating interactive tasks on their own (figure 8) that help them to fix studied material, to develop cognitive activity, to form professional and per-

Figure 5: Score journal on the portal of distance and mixed learning Moodle.

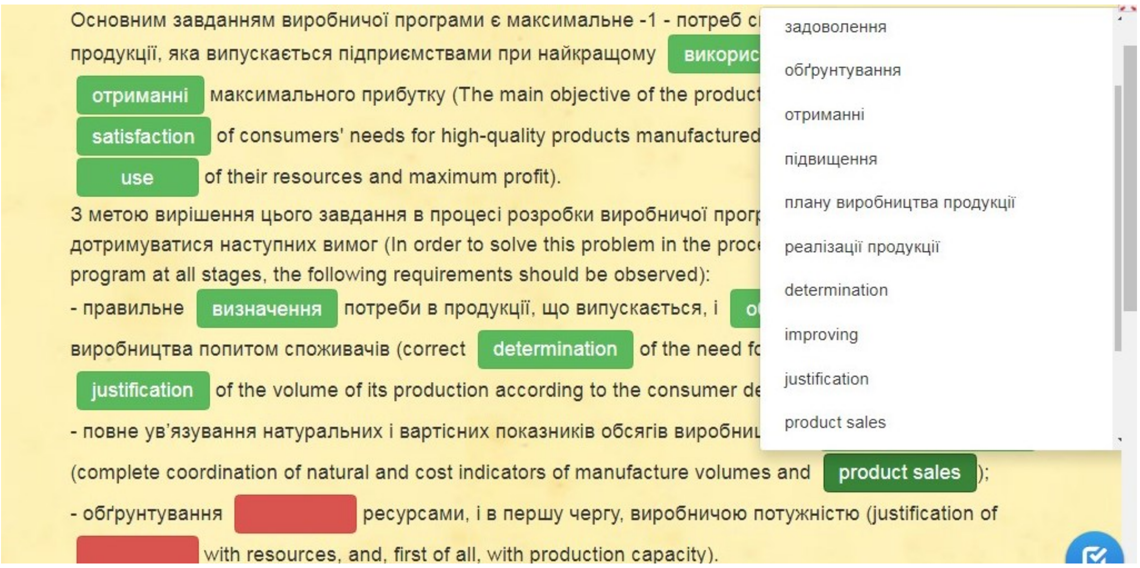

Figure 6: Example of interactive task “Close text”.

sonal qualities.

Joining the possibilities of the Moodle system and online services guarantees the improvement of any training course, gives the ability to make it more productive, and the educational process more interesting and high quality for higher education applicants. The result depends on the professionalism of teaching staff, given the number of such educational services (Korniienko and Fedchenko, 2016).

5 CONCLUSIONS AND FUTURE WORK

In conclusion we can say that the implementation of the information and communication technology in education withe-learning management system allows improving effectiveness of the education. The use of LMS allows better cooperation among the learners, the tutors and the students. The accessibility,usability and student collaborative learning are improved. Higher motivation among the students and the teachers is achieved (Nedeva, 2005).

The use of network technologies in the process of training of specialists in economic specialties allows the instructor to design the optimal strategy for studying the discipline and contributes not only to the assimilation of knowledge, abilities, skills, forms of professional behavior, but also to the formation of a certain structure of personal qualities.

Study of the conditions of formation of professional competence of future specialists in economic

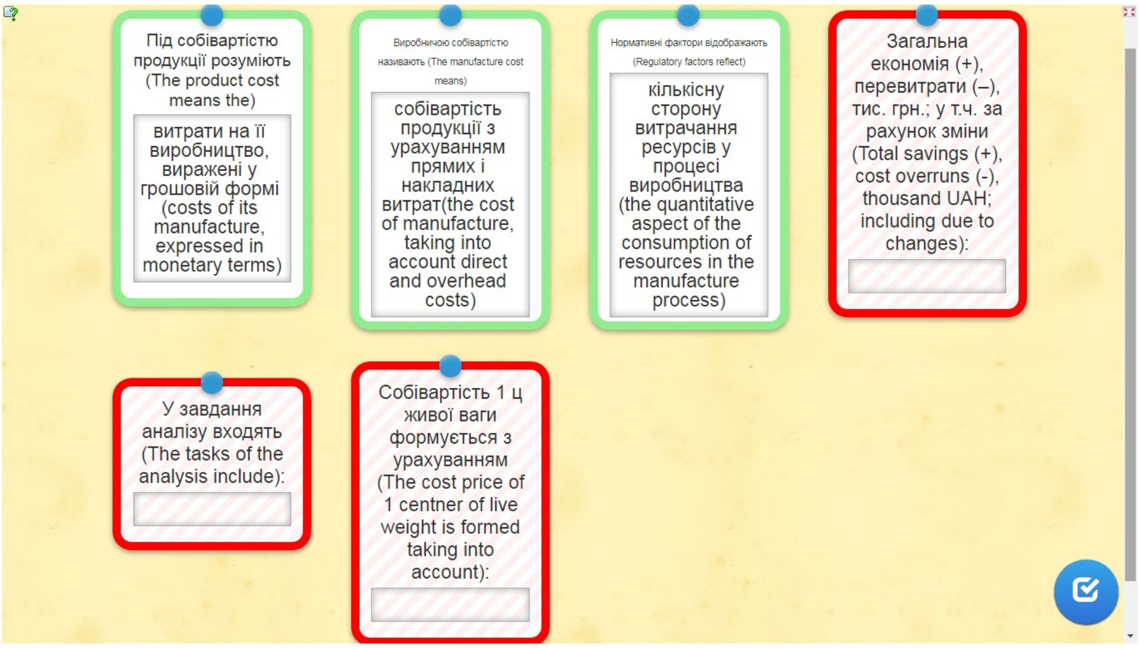

Figure 7: Example of interactive task "Freetext input".

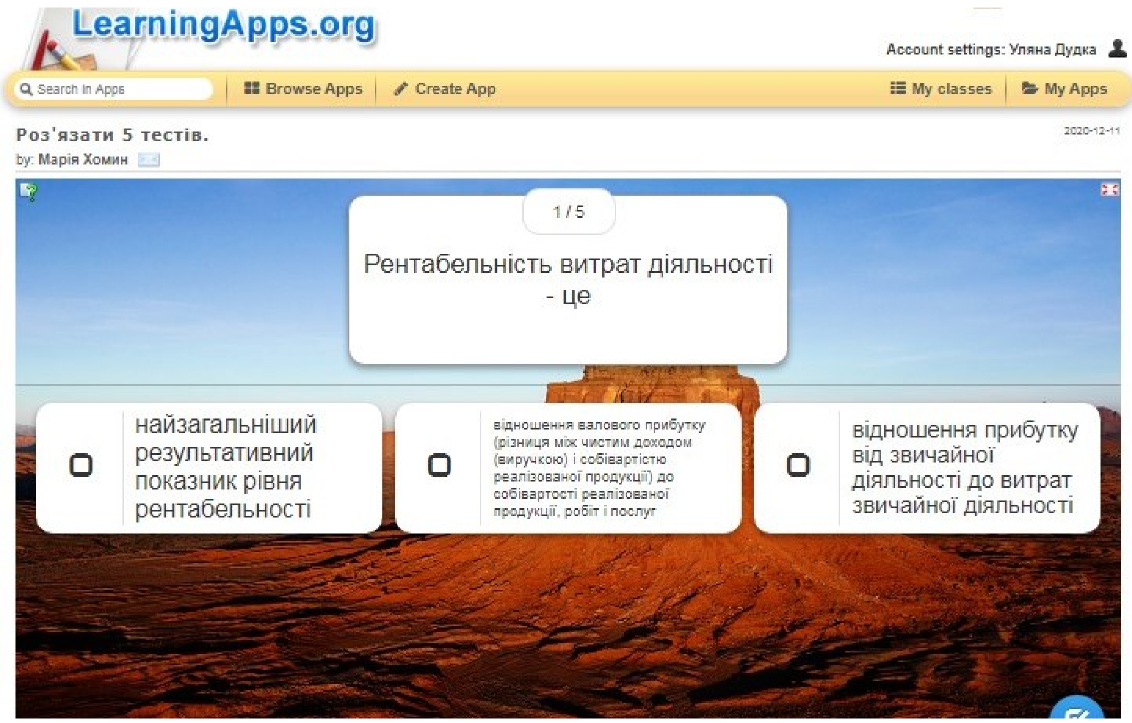

Figure 8: Example of interactive task "Multiple-Choice Quiz" on the LearningApps.org online service.

specialties by means of network technologies allowed to establish that the introduction of educational and methodical complex, which includes distance learning courses developed by the Moodle system tools, using a modular approach in combination with interactive tasks of the LearningApps.org, presentation of knowledge as a dynamic, multimodal structure, which involves future specialists in economic specialties, helps them gaining experience in self-replenishment and updating professional knowledge, personal involvement in this process and responsibility for it (Boliubash, 2012).

It is proved that usage of gamification approach (an approach of usage game mechanics in non-gaming activities like learning access) in e-courses has many advantages: the activities are varied and flexible; they motivate students to study; provide high level of engagement; helps to practice real-life situations; effectiveness. Platform LearningApps.org proposes 20 templates to be used in e-courses with the help of SCORM package. Their advantages for teachers are easy to use, available anytime and anywhere, big variety of examples which can also be used. The advantages for students are: 1) they experience "fun" during the game and still learn if the level of engagement is high; 2) e-Learning is interactive; 3) better learning experience (Yurzhenko, 2019). The use of the LearningApps.org online service in the Moodle system in combination with other means of information technologies provides the maximum possible interrelation of pedagogical, scientific and teaching staff and higher education applicants of economic specialties.

Poll of the education applicants on the use of interactive tasks of the LearningApps.org online service in the Moodle system and the results of evaluation made it possible to conclude that education applicants are more interested in studying and fixing the educational materials.

Activation of cognitive activity and interest in future specialists in economic specialties is caused by the LearningApps.org online service, as it allows you to develop interactive tasks, using templates, which saves a lot of time, allows you to quickly make your own posts in the created multimedia applications (exercises, tasks), without using and having special knowledge of high-level programming languages, generate a QR-code for each interactive task, which provides a quick transition to the service to perform the exercise, working online or offline without access to the Internet and provides a number of other benefits of implementing the didactic process online.

In the process of didactic activity of future specialists in economic specialties, the use of Moodle has a number of advantages: after personalization, higher education applicants have constant access to study material from different disciplines, which is very important, because they do not need to move from one learning platform to another; the possibility of the Moodle system to embed external resources helps in the teaching of economic disciplines, because the use of, for example, interactive tasks of the LearningApps.org online service helps to form knowledge, abilities and skills in higher education applicants, develops their creative potential in the form of games, when they are interested in achieving high results. An important thing is that by inserting the interactive tasks of the LearningApps.org online service into the Moodle system, the lecturer, instead of having different platforms and monitoring points, can observe the progress of education applicants and view the results of completed tasks in a centralized place.

We plan to outline the methods of using the tasks of the LearningApps.org online service in further scientific researches that will be put into the Moodle system using the links.

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Peculiarities of using LearningApps Service in the Process of Developing a Motivational Component of Professional Training of Future Professionals in Terms of Adaptive Learning

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Keywords: Information Technologies, Educational Resources, Web 2.0 Technologies, LearningApps.org, Interactive Exercises, Professional Training, Motivation.

Abstract: The article considers the adaptive learning system as a system that can help each student to achieve the optimal level of intellectual development in accordance with his natural abilities and inclinations. The main advantages of using interactive exercises in the process of organizing educational activities using the technical capabilities of the LearningApps service are considered. The paper demonstrates the ways of using the appropriate service in the process of implementing a personalized approach to educational activities, presents the results of an empirical study focused on the implementation of the LearningApps service in the process of studying first-year students of psychological disciplines. Statistic data show the feasibility of using the service LearningApps in the development of the motivational component of professional training of future professionals in the conditions of adaptive learning.

1 INTRODUCTION

At the present time, information and communication technologies are becoming an integral part of the process in various subject areas and social practice. The development of modern education is inextricably linked with the informatization of society, and information and communication competence is considered as a priority. Education is one of the basic elements of the ecosystem of (digital) innovation and the digital economy in general. Creating, attracting and retaining a sufficient number of professionals with new technologies is needed to achieve a competitive advantage in the digital world. With the advent of new technologies there is a demand for new competencies (Semerikov et al., 2020).

There is a growing shortage of skilled workers, and the acquisition of digital skills is becoming a basic need. For example, the shortage of staff is currently one of the main obstacles to the development of AI: according to Bell (Bell, 2018), there are no more than 22,000 PhD professionals in this field worldwide today, and only in the United States there are more than 10,000 vacancies. According to Smit et al. (Smit et al., 2020), by the year 2030 in Europe, working time will increase by 20% with the use of innovative technological skills in any industry or social practice and by 65% with the use of basic technological competencies. According to the same study, over the next 10 years, 90% of jobs will require digital skills in professional self-realization of specialists in various industries. Demand will also increase for workers with social, emotional and motivational skills – by about 22% across all industries in Europe by the year 2030. Accordingly, the cognitive, emotional-volitional and motivational component of the implementation of information competence of a specialist in the changing conditions of professional practice development will become a key standard of professional suitability and competitiveness.

The modern process of professional training of a specialist in the context of the transformation of education and the spread of blended learning technolo-

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gies is already unthinkable without the widespread use of innovative technologies that are at the stages of revolutionary development. Their development creates the basis for the implementation of the latest educational programs at a qualitatively new level, initiates and develops the emergence of new educational practices, which, in turn, contributes to the transformation of education as a whole. The priority of higher education development is the implementation of modern computer technologies that provide access to a network of high-quality databases, expand the ability to perceive complex information, focus on individual psychological characteristics of students and rely on the principles of personification of blended learning. This is done by creating individual training programs of various levels of complexity, depending on the specific needs and features of using the Internet's capabilities. Thanks to information and communication technologies, today we have more opportunities to use the latest services in the educational process and more effectively organize individual and group work of students. Accordingly, the issue of implementing modern information technologies in the process of professional and personal development of a future specialist is important.

The use of modern information training systems contributes to the individualization of the educational process and creates conditions for differentiated learning depending on the level of training, psychological characteristics and needs of students. This makes it possible to carry out automated control of knowledge and formation of certain professionally important competencies and adapt the learning process to specific educational tasks and individual characteristics of the student. In this regard, it is important to study systems and services focused on the implementation of components of adaptive learning as one of the promising areas in the modern information system.

2 LITERATURE REVIEW

The realities of modern times that world civilization has encountered in connection with the pandemic have been particularly acute in the field of education. In a fairly short period of time, teachers and students were forced to radically change the forms, means, methods, techniques and ways of teaching. In the context of pandemic restrictions, the priority direction of the reformation of the higher education system has become an urgent transition to a blended form of education, that is, a structural-logical and holistic combination of classroom classes and distance learning using modern services, interactive and cloud technologies (Fernández Cruz et al., 2020).

Current issues of using Web 2.0 mobile applications (in particular LearningApps.org), the integration of information and communication technologies in the process of teaching students were considered in (Harmandaoğlu Baz et al., 2019; Malchenko et al., 2021; Shea et al., 2006; Ullrich et al., 2008). At the same time, the issue of optimizing the training process of future specialists, taking into account their individual psychological and typological characteristics, and introducing an adaptive learning system remained important. Thus, an important direction of education reformation in the context of the introduction of adaptive learning is the development of a constructive model for building individual learning scenarios based on the student model and maps of user knowledge gaps. The student's model shows the main parameters of their level of training and individual cognitive features. It allows to implement a number of new technologies for the formation of individual calendar plans of repetition of themes, construction of individual trajectories of forgetting processes by the student of the received knowledge, and development of individual scenarios of adaptive testing (Tomashevskiy et al., 2021).

As part of the analysis of empirical, practice-oriented research, it is quite interesting to research aims to develop an adaptive learning system using Hybrid Learning Diagnostic Approach (HLDA) to diagnose and detect learners' learning styles according to the criteria in the Index of Learning Style (ILS) into 3 dimensions (1) active-reflective, (2) visual-verbal, and (3) sequential-global (Singpant et al., 2020). Empirically, researchers prove that the Self-Evolving Adaptive Learning (SEAL) system for personalized education at scale is quite effective in the process of personalizing the educational environment (Liu et al., 2020) and highlight the key structural peculiarities of the practical implementation of the adaptive learning system, taking into account the individual characteristics of dyadic interaction between teachers and students in order to effectively organize the formation of the future specialists' professional competencies (Cavanagh et al., 2020).

As part of the practical implementation of the concept of personalized learning Valko and Osadchyi (Valko and Osadchyi, 2020) propose the introduction of elements of the theory of artificial neural networks into the educational process. Based on the network, according to the Semerikov et al. (Semerikov et al., 2019), it is possible to build a model of the educational process, which will significantly increase the teacher's control over the learning process. Moreover, Valko and Osadchyi (Valko and Osadchyi, 2020) believe that the network can adapt to a specific educational task, individual characteristics of the student and teacher. The authors constructed a mathematical model of the educational process using modern information technologies and neural networks. Their use is based on the developed criteria for successful completion of various stages of the educational process. Such criteria are intended for both the student and the teacher (Osadchyi et al., 2020a).

According to Tkachuk et al. (Tkachuk et al., 2020), the active transition of modern higher education to the digital plane encourages the processes of adapting the audience response system and mobile multimedia development tools for use in the educational environment of universities. Tkachuk et al. (Tkachuk et al., 2020) developed, tested, and confirmed the effectiveness of methods for applying audience response systems using the example of Plickers and mobile multimedia development tools using augmented reality tools.

As part of optimizing the implementation of the competence approach in the process of professional training of the future specialists in the context of digitalization of education, Vakaliuk et al. (Vakaliuk et al., 2020b) propose the implementation of game simulators in order to develop soft skills competencies. Vakaliuk et al. (Vakaliuk et al., 2020a) present the possibilities of using the Game Dev Tycoon simulator for the development of professional soft skills in future software engineers in higher educational institutions, describe in detail how students develop professional soft skills in the process of passing game simulators.

Thus, the actualization of the need of the modern educational space in the development and implementation of a comprehensive system of adaptive learning in the context of digitalization and active development of information and communication technologies, augmented reality technologies encourages further scientific research on the development of principles, methods, means of reorganizing distance and blended learning systems, taking into account the individual psychological characteristics of participants in the educational process.

In the context of actualizing the problem of introducing adaptive systems in the process of training future professionals, the issue of developing internal positive motivation and focus on professional self-realization is important, which is a key component of the future specialist's competitiveness in transforming social processes. As part of a multi-vector interdisciplinary study, the purpose of this article is to comprehensively analyze the features and effectiveness of the service LearningApps in the teaching of disciplines in adaptive learning, to develop the motivational component of professional development of future specialists in socionomic professions (for example, future psychologists).

3 METHODS

A comprehensive interdisciplinary study was conducted within the framework of scientific cooperation between the STEAM-laboratory and the Laboratory of psychophysiological research of Bogdan Khmelnitsky Melitopol State Pedagogical University (Osadchyi et al., 2020b). The methods used in the research process are: the method of analysis of theoretical sources, the study of advanced psychological and pedagogical experience of foreign and domestic scientists on the problem of implementing a competency-based and personality-oriented approach in the context of implementing a system of adaptive learning of students, empirical analysis of the impact of the LearningApps service on the development of the motivational component of professional training of future specialists in the context of adaptive learning; generalization and conceptualization to formulate the main provisions of the study; generalization and evaluation of the results of an empirical study.

4 RESULTS

4.1 Analysis of the Peculiarities of the Implementation of the System LearningApps in the Process of Training Future Professionals in the Conditions of Adaptive Start

LearningApps.org it is a Web 2.0 application to support learning and the teaching process through interactive modules. Existing modules can be directly integrated into the training content, and they can also be modified or created in the foreground mode. The goal is also to collect interactive blocks and make them publicly available. For this reason, such blocks (so-called applications or exercises) are not included in any programs or specific scenarios. They have their own value, namely interactivity. These modules can be used directly as learning resources or for independent work and self-assessment of students. The LearningApps service has a fairly user-friendly interface that allows you to easily create tasks based on templates. A large number of templates are available on this service, which contributes to a variety of task development. It is worth noting that this service is free of charge. The LearningApps service provides the ability to get code so that interactive tasks are placed on the pages of websites or blogs of teachers and students. The advantages of using the corresponding service are a large number of languages (including Ukrainian), a large range of tasks in complexity, tasks on almost any topic, a convenient search engine, the ability to intuitively use the service, user-friendliness of the interface, free of charge, frequent updating of task templates, the ability to combine students into classes and students into groups (Nazarenko et al., 2020). One of the advantages of the LearningApps environment is the ability to download created exercises to your own computer: in SCORM format – upload them to a distance learning system or use them on a computer without the Internet, iBook Author – for using exercises on an iPad without the Internet, Developer Source – for changing exercises at the programming language level. To date, the service offers about 30 different templates, which is enough to implement many methodological ideas. All templates are divided into 5 groups: selection, division, sequence, completion, and online games (Foster and Shah, 2021). All exercises in this service are divided into categories: "Find a pair", "Classification", "Numerical straight line", "Simple ordering", "Free text answer", "Image fragments", "Quiz", "Fill in the blanks".

In the service LearningApps.org there are such tools that allow teachers to prepare high-quality electronic visual aids, audio / video materials, as well as remotely communicate with students and colleagues:

- Notebook – the simplest text editor;
- Pinboard – an application for placing multimedia content (text notes, pictures, audio, video) with imitation of attaching stationery buttons to a cork board;
- QikPad – is an online editor where multiple Internet users can work together;
- Mindmap – an easy-to-use and visual graphic editor of mental maps. It can be used both to demonstrate pre-compiled maps, and to create a mental map in a training session;
- Audio / video content – an application that allows you not only to download audio / video files, but also to build into applications. For example, on LearningApps, you can create applications where you need to guess a certain property based on sound or graphic features. It is also possible to add questions to the video that students must answer after watching it;
- Calendar – for scheduling in the form of a table;
- App grid – is an app to create a collection of multiple exercises to share with other users;
- Chat – for online communication.

In the process of filling the educational space with interactive learning components the teacher can use a particular module to solve specific problems in their subject area (Hernández-Lara et al., 2019):

- to consolidate theoretical and practical knowledge, interiorize theoretical knowledge into practical skills by solving practice-oriented and competence-oriented tasks, their verification and introspection;
- can serve as a convenient shell for organizing various competitive and project events;
- to activate the cognitive activity of students, increase the motivational component of the professional development of a future specialist;
- tasks can be created and edited online using various templates;
- application of various types of intellectual interactive tasks, taking into account the individual psychological characteristics of students, by building a psychological portrait based on the results of a psychodiagnostic examination;
- create an account for students – the teacher can create a group for which he will collect "exercises" and invite students to individual or group activities;
- ready-made exercises are easily integrated into blogs and websites, and can also be used when working off-line;

Comparing the LearningApps website with other services, it becomes obvious that it is the best choice if there is a need to develop interactive, personalized tasks for students. The analysis of existing Internet services allowed us to define LearningApps as a convenient tool for creating an interactive course from a large number of templates of various categories and complexity, which can be used for free to present, consolidate, verify and summarize the acquired professionally oriented competencies of future specialists. Considering the advantages of using the LearningApps service in the process of professional training of future specialists and in the context of the implementation of the scientific development "Adaptive system for individualization and personalization of professional training of future specialists in blended learning" by leading specialists of the Department of Informatics and cybernetics, the Laboratory of health psychology and the Department of the Psychology of Bogdan Khmelnitsky Melitopol State Pedagogical University during 2019–2020 a set of interactive exercises, tests, and tasks was developed to increase the motivation for learning among first-year students and future psychologists. The corresponding interactive exercises were implemented from September to December 2020 as part of the teaching of the courses "Introduction to the specialty of psychology" and "Age psychology with a practical course". In this service, a "Portfolio" of the teacher was created for individual modules, filled with professionally oriented exercises, tests, games, crosswords, competence-oriented tasks, access to which the teacher provided students according to a specific lesson. Students performed tasks both individually and in a group form of work. In the context of quarantine restrictions from October to December 2020, the learning process using the LearningApps service fnd Moodle has become extremely important. In the context of increasing the role of independent work in the educational process with the help of the LearningApps service, the teacher could stimulate the development of positive motivation and interest in learning, which directly affects the formation of a positive "I concept" and professional orientation of the future specialist, the development of critical and creative thinking, media literacy, the formation of IT competence, social and communication skills, in particular the following skills:

- analysis of material, facts, comparing, comparison of facts, phenomena;
- selection of information from various sources;
- establishing associations with known facts, phenomena, establishing associations with new qualities of objects, phenomena, etc.;
- ability to use the logic of the sequence of actions performed to solve the problem, to build the logic of the decision being made, the internal logic of the problem being solved, and so on;
- ability to view the object under study, the problem in its entirety;
- systematization and generalization of the material;
- working in a team in the process of solving project tasks, mutual evaluation.

Especially popular among students in the process of completing tasks were such types of exercises as: "Find a couple", "Classification", "Simple ordering", "Free text answer", "Quiz", "Fill in the blanks", "First million", "Puzzle", "Crossword", "Guess the word", "Horse racing", "Couples", etc. (figure 1)

As part of the corresponding service, an interactive game "The smartest" was organized and held at the final lesson in the disciplines "Age psychology with a practical course" and "Mental development of the individual with a practical course". The main goal is to integrate the acquired knowledge, update the mental potential, motivate applicants to study the material, involve them in the implementation of scientific and search activities. During the lesson, applicants participated in an exciting game. When opening tasks (problem-search, analytical-synthetic, problem situations, tests), they had to mobilize the knowledge and skills gained during training on the topic in order to successfully solve extraordinary, creative tasks, relying on the interiorization of the acquired knowledge, cohesion and creativity. Such an interactive form of conducting the lesson allowed to consolidate knowledge of the discipline, develop internal motivation for self-education, self-improvement, as important components of professional maturity, contributed to the development of cognitive interest, logical thinking, attention, sociability, activity, interest and emotional experiences of applicants.

The service also provided an opportunity for the teacher to keep statistics of exercises performed by students, to contact each student online via SMS, to assess the correctness of tasks of different levels of complexity, taking into account individual psychological characteristics of the individual.

4.2 Results of the Implementation of the Service LearningApps in the Process of Developing a Motivational Component of Professional Training of Future Professionals

In order to analyze empirical and statistical data of the study of the effectiveness of implementing the LearningApps service in the process of training future specialists and the impact of the corresponding service on the motivational component of professional training of future specialists in adaptive learning, a psychodiagnostic survey of first-year students was conducted. 40 first-year students took part in the study. In September, a psychodiagnostic study was conducted on the basis of the Laboratory of psychophysiological research in the process of implementing the "Adaptive" program of psychological support for first-year students . The second stage of the psychodiagnostic study was conducted in December using Google Forms after completing the study

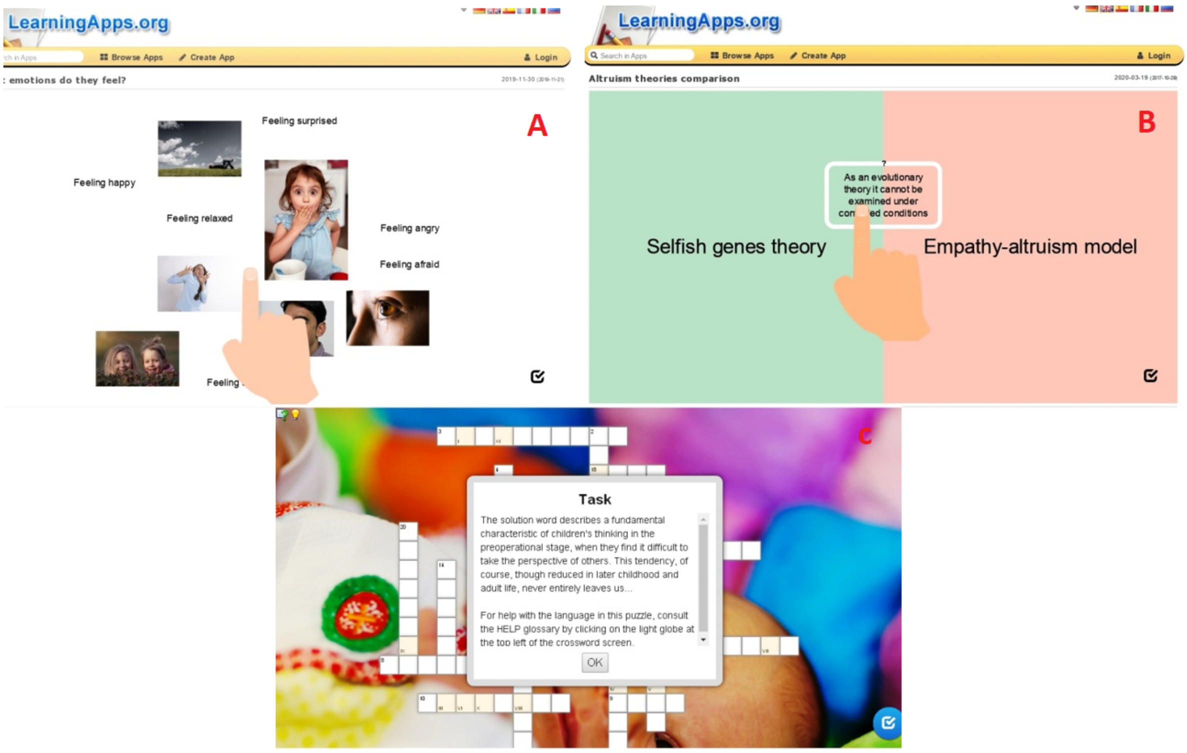

Figure 1: Examples of practice-oriented tasks that are implemented in the learning process using the LearningApps service: a) Exercise "Determination of nonverbal markers of human emotional states"; b) Exercise-QUIZ "Theories of altruism in psychological practice"; c) Exercise-crossword "Features of the development of cognitive processes of personality in ontogenesis".

Table 1: Determining the dominant motive of Higher Education.

Motives for studying at the HEI	**Number of students at the beginning of studying training courses using the LearningApps service (%)**	**Number of students at the end of studying training courses using the LearningApps service (%)**
Gaining knowledge	20.4	32.4
Mastering the profession	29.8	41.6
Getting a diploma	49.8	26

of disciplines using the LearningApps service. In order to analyze changes in the structure of the motivational component of professional training of future specialists in the context of adaptive learning, the following psychodiagnostic methods were used: "Motivation of studying at a HEI" (author T. I. Ilina) and the method "Motives for choosing a profession". To determine the significance of the changes that occurred after the introduction of the LearningApps service in the training system for future specialists, we used the G-criterion. Based on the results of statistical processing of empirical data, significant changes in the dominance of learning motives in higher education were revealed (table 1).

The table shows that at the beginning of studying training courses, the dominant motive among students is "obtaining a diploma" (49.8%), that is, the desire to get a diploma with formal assimilation of knowledge, which is directly related to the socio-economic situation of modern Ukrainian society and acute problems of employment in the specialty. Only a small number of respondents showed a desire to acquire knowledge (20.4%) and master the profession and form professionally important qualities (29.8%), which is due to the desire for professional self-realization and self-actualization of future specialists in the field of practical psychology. The dominant motive for studying in higher education for the majority of respondents (41.6%) after completing the training course using the LearningApps service is the desire to master the profession and form professionally important qualities, which is due to the desire for professional self-realization and self-actualization. Also, according to the results of correlation analysis, it was revealed:

Table 2: Determining the dominant motive of Higher Education.

Motives for studying at the HEI	**Number of students at the beginning of studying training courses using the LearningApps service (%)**	**Number of students at the end of studying training courses using the LearningApps service (%)**
Internal individually significant	19	34.5
Internal socially significant	18	37.5
External positive	27.5	19
External negative	35.5	9

typical shift – positive, negative shifts – 13, $n = 94$.

$$G_{contr} = \begin{cases} 38(p \leqslant 0,05) \\ 35(p \leqslant 0,01) \end{cases}$$

G_{emp} – a number of untypical shifts, so $G_{emp} = 13, G_{emp} < G_{contr}$. It means that H_0 is not proved, but H_1 is accepted.

According to the empirical data presented in table 2, it was revealed that at the beginning of training, there is a tendency for students to dominate the external negative motive (35.5%) (uncertainty, lack of internal personally significant meaning in choosing a profession). For 27.5% of the subjects studied, the main one was an external positive motive, that is, orientation to the growing social significance, and along with it attractiveness, of the profession of a practical psychologist. Only 19% of students showed a focus on self-realization of internal potential, on getting pleasure from the process of professional activity; and 18% – the desire to grow professionally, to benefit people, in order to gain social significance. After implementing interactive tasks using the LearningApps service, the dominant motive for choosing a profession was the desire to grow professionally, benefit people, in order to gain social significance (37,5%), that is, an internal socially significant motive. Using the G-criterion, we found that when $n = 74$. A typical shift is positive. Negative shifts 17.

$$G_{contr} = \begin{cases} 29(p \leqslant 0,05) \\ 26(p \leqslant 0,01) \end{cases}$$

G_{emp} – a number of untypical shifts, so $G_{emp} = 17, G_{emp} < G_{contr}$ It means that H_0 is not proved, but H_1 is accepted.

Accordingly, it can be concluded that the organization of educational activities with the help of interactive technologies and information systems stimulates the development of cognitive motivation, the desire for professional growth and self-development.

5 CONCLUSIONS

Currently, the problem of enhancing the educational activities of students is urgent, therefore, an important role in the learning process is assigned to interactive learning technologies. At the present stage of development of society and the higher education system, when the goal of education is to create conditions for the maximum development of the personal potential of a future specialist, social services Web 2.0, the main features of which are interactivity and socialization, can help optimize the teaching process and stimulate the development of a positive motivational construct. In relation to the process of professional training, LearningApps represents a qualitatively new approach to building the educational process.

The advantage of LearningApps lies in the ability to attract all students to participate in the educational process, not only as consumers of educational content, but also as its active creators. LearningApps technologies contribute to the implementation of the student-centered principle of building the educational process, when the student is at the center of the pedagogical process, who becomes more autonomous in terms of managing the educational process and more active in creating educational information and interacting with other participants in the learning process. LearningApps is an easy-to-use online service that can be used to perform and create interactive exercises in the process of higher education. The teacher's use of interactive tasks makes it possible to significantly increase the activation of students' mental activity during the perception and assimilation of educational material. This is achieved by increasing the degree of clarity, problematic presentation of the most important provisions of theory and practice, the active position of students and their high motivation and interest in the process of completing tasks. The use of modern innovative technologies, in particular interactive learning technology, opens up broad prospects for deepening the theoretical knowledge base, strengthens the motivational orientation to the study of academic disciplines and, in particular, psychology, provides mastery of personal self-development skills, the ability to think, develop creatively, and design new things (Roodt and Ryklief, 2019). The results of the empiric study proved the expediency of using the LearningApps service in the process of developing the motivational component of professional training of future specialists in the context of adaptive training. As a result of systematic work on the use of the LearningApps.org website in the process of assimilating educational material within the framework of professionally oriented courses, students develop their own style of using them, constructing, which gives the educational process a creative character, contributes to the development of the personality of its individuality and uniqueness, interiorization of the theoretical basis and practical skills, which stimulates interest and internal involvement in the educational process. Based on the results of the implementation of the components of LearningApps in the process of professional training in the minds of the adaptive development, the development of the motivational component of the professional development of the potential faults in the empirical indicators. In the process of analyzing the middle of the respondents, a positive directness and involvement in the initial process was revealed, the readiness and preparation of the professional competence to obtain professionally important competences and active learning from the virgin problem-specific and practical training of the employees. Accordingly, the use of the LearningApps service in the context of adaptive learning makes it possible to overcome the intellectual passivity of students, makes it possible to increase the efficiency of educational activities and the positive motivational orientation of future specialists.

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Development of Future Foreign Language Teachers' Soft Skills by Means of ICT in Ukrainian Universities

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Abstract: The aims of this paper are to overview the main aspects of soft skills development by means of ICT in higher education Ukraine. The ways of future foreign language teachers' soft skills development are identified within the core and selective parts of the curriculum of Bachelor's level. The article discusses the essence of soft skills, their difference from hard skills and the main recent tendencies of their development by means of ICT in Ukrainian higher education. The idea of creating educational-professional hub and its programme aimed at future foreign language teachers' soft skills development is outlined.

1 INTRODUCTION

Significant changes in science, economics and society for the last two decades have influenced the development of the education sector, setting the objective of training employable professionals who are able to respond to today's challenges and adapt to various working conditions. Recently, in Ukrainian higher education the so-called soft skills and their importance for the employability of graduates are frequently discussed. According to the opinion polls, most employers prefer a candidate who has developed soft skills, while purely professional skills (hard skills) are of primary importance for only 20% of the employers (Mitchell, 2008). The reason for this is that having professional knowledge and skills (hard skills) is not enough to perform a wide range of professional tasks. A person must have the universal skills needed in any activity: the ability to think critically, find the necessary information, work in a team, be resistant to stress, rationally plan his or her time, etc.

The European Commission declared that "a large number of Europeans, particularly highly-qualified young people, work in jobs that do not match their talents and aspirations. At the same time, 40% of European employers report that they cannot find people with the right skills to grow and innovate" (ec.europa.eu, 2016). Council Recommendation on Key Competences for Lifelong Learning (EC, 2018) was suggested as the way to help more people "acquire the core set of skills necessary to work and live in the 21st century with a special focus on promoting entrepreneurial and innovation-oriented mind-sets and skills" (ec.europa.eu, 2016). The issue is especially relevant to Ukrainian context as there are more and more employers focusing on European standards and requirements for employees' hard and soft skills.

In Ukraine, the first sociological investigation of digital skills demonstrated that 53% of Ukrainian population are below the average mark, 15.1% of them do not have any digital skills at all (Diia, 2019). Digital skills are soft skills for all except IT specialists; moreover they can help to develop a range of other soft skills.

Such skills will be useful not only in professional activities, but also in everyday life, and will help to better arrange the living space, solve various life issues as well as establish relationships with others. The study of the soft skills development has become increasingly popular among scientists. On the one hand, scientists and managers who are engaged in business research and looking for the ways to train competitive workers discuss the feasibility of soft skills development. On the other hand, the importance of soft skills development is considered not only as a significant advantage in the business sphere, but also in any other field, including education.

Any teacher must have his or her soft skills developed as they interact with various people every day: students, parents, colleagues. It is important for them

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to be able to build relationships with others, present themselves and their ideas, have leadership qualities. The teachers face unpredictable situations every day, so they are expected to act effectively both inside and outside the school. The ability to efficiently behave in both typical and critical situations is one of the characteristic features of the developed soft skills of a teacher (Konovalenko and Goncharova, 2018). New trends in education lead to changes and the search for new models of future teachers' training, which focuses on the student-centredness, forms the image of a new generation teacher, teacher-facilitator, colleague, educator, project manager, communicator, researcher, innovator. Without developed soft skills it will be impossible for a teacher to perform this role.

The most prominent feature of the modern educational process is the active involvement of ICT in the classroom, which is undoubtedly an extreme need of the information society. The continuing development of digital technologies provides teachers with unlimited opportunities for the implementing, development and use of new methods and technologies in the educational process, helping to improve it, adapt to new labour market requirements, and to make the process of acquiring knowledge by students more engaging and productive.

The use of ICT as one of the tools in the process of future foreign language teachers' soft skills development has not been revealed in the researches profoundly enough. There are a lot of research and scientific publications on the use of ICT in the process of learning foreign languages in higher educational institutions or secondary schools. Nevertheless, the use of ICT as a means of soft skills development has not been sufficiently studied, thus the topic of our research is relevant in the context of recent world events and challenges the system of higher education faces today.

The *aim* of the article is to review the experience of future foreign languages teachers' soft skills development and to outline the effective ways of their development by means of ICT in Ukrainian universities.

2 METHODS

The methodology of our investigation is presented with the standard procedure of action research as it is one of the most dynamic, flexible and effective ways of implementing new ideas in the education sphere.

According to Mertler (Mertler, 2018) we are following such stages:

- Identifying and limiting the topic
- Gathering information
- Reviewing the related literature
- Developing a research plan
- Implementing the plan and collecting the data
- Analysing the data
- Developing an action plan
- Sharing and communicating the results
- Reflecting on the research process.

This paper presents the beginning stage of the study and action research cycle. So, it reveals the topic relevance, discusses the world and Ukrainian experience within the issue, describes the research plan and the first data obtained.

This research describes the attempt to accumulate the recent experience of educational community to face the challenges of new educational environment, to elicit what students and university teachers felt and how they reacted to emerging factors, to synthesise and communicate issues to be solved, and thereby to stimulate implementing the best practices of soft skills development by means of ICT. We suggest expanding the lens of focus from individual effective practices of university teachers to common use and creating the new model of future foreign languages teachers' soft skills development in the process of their training in Ukrainian universities.

We are going to involve all categories of stakeholders into our research as it is necessary to know the needs of students, university teachers, university management, their future school students, school administration, parents and authorities responsible for education on national level. Thus, besides of literature review, practical experience study, we need qualitative and quantitative data as well as mixed methods to engage the stakeholders to eliciting and synthesising all relevant data and create the model of future foreign languages teachers' soft skills development by means of ICT.

In this article we reveal our experience of finding the answers to such research questions:

1. What is 'soft skills'?
2. How have they been changing and what influences their change?
3. Which soft skills are especially important for future foreign language teachers?
4. What are the best practices for the development of soft skills?
5. What issues have not been solved yet?
6. How can the use of ICT contribute to the development of soft skills?

The answers to these questions will help us to collect the necessary data and start designing the model of future foreign languages teachers' soft skills development by means of ICT relevant to Ukrainian higher education.

3 RESULTS AND DISCUSSIONS

The concept of soft skills has become an integral part of the labour market in many areas of the economy, and there are some other closely related terms.

Cinque (Cinque, 2016), researching the development of skills which we call 'soft skills', provides a list of terms used by different organizations in different periods:

Analysing these terms, we can see that they contain the words 'future', 'life', 'social', 'society', i.e. the presence of these skills is seen as a guarantee of the success in the life of a particular person, which leads to the success in society. And the verbs 'transversal' and 'transferable' indicate the universal nature of these skills, the ability to use them in various activities. The term 'soft skills for talent' emphasizes that the development of soft skills gives a person more opportunities to realize his or her natural abilities, and as a result increases success in the career life and promotes self-realization, which in turn is the key to harmonious and happy life.

The Oxford Dictionary defines 'soft skills' as "personal qualities of a person that contribute to successful communication with other people: the ability to work together, enthusiasm, emotional intelligence" (www.oxfordlearnersdictionaries.com, 2021). At the same time, life skills are defined as "skills necessary or extremely useful for managing daily life: the ability to work in a team, solve problems, literacy and arithmetic skills. They also include such vital skills as the ability to cook or use a washing machine" (www.oxfordlearnersdictionaries.com, 2021). Thus, although the terms 'soft skills' and 'life skills' are closely related, there is a difference between them. The use of the term 'life skills' is more acceptable when we talk about the formation of skills necessary for a person primarily for independent living, adaptation to living conditions, solving life and everyday problems. While the concept of 'soft skills' is more often used in the context of training a person for future professional activities.

The concepts of soft skills and hard skills originated in the 1960s and 1970s in military affairs and were expressed in the doctrine of "Military Training Design Systems": hard skills were used to denote machine skills and soft skills – to work with people and papers. Subsequently, the terms began to be actively used in business. Robles (Robles, 2012) considered the need to develop soft skills in students as one of the important factors in preparing them for successful business communication. Mitchell (Mitchell, 2008) wrote about the importance of integrating soft skills into business school curricula, which would contribute to the further successful employment of students and their competitiveness in the labour market of the 21st century. There is a growing talk about the need to develop soft skills in any profession and emphasise the need to include the development of soft skills in educational programs as one of the mandatory components, along with training for specialised professional skills.

Thus, the modern education faces the necessity of training primarily teachers who have well-developed hard and soft skills, and who are able to contribute to the further effective development of these skills of their future students. That is why in the Regulations on Accreditation of Study Programmes in Higher Education, one of the important sub-criteria (sub-criterion 2.6) is the following: "The study programme envisages the development of soft skills in students that meet stated objectives" (NAQA, 2019), which will help graduates succeed in their workplace.

The ratio of soft skills and hard skills may differ for individual professions. There are professions that provide accurate calculations, drawings, experiments, and in these professions the hard skills are more important, because the level of their development mostly influences the result of the task fulfilled. Whereas the professions which are directly related to communication with people, planning, trade, art, require more focus on soft skills. However, it should be noted that, for example, researchers in a laboratory with advanced communication skills will have a better chance of professional growth, as they will be able to present themselves and their ideas better than their colleagues, whose soft skills are less developed.

When compared with the hard skills, the soft skills are based more on personal values and in response to certain actions the models of human behaviour are engaged. The development of soft skills is slower and reaching a certain level is not guaranteed. Soft skills under certain conditions have a tendency to reverse development, while hard skills have almost no such tendency (Dlugunovych, 2014).

There are many universal skills that may be needed in a profession and for life in general. A study by Simona (Simona, 2015) among teachers in the UK, Denmark, Spain, Romania and Portugal identified such life skills as:

- Numeracy skills
- Literacy and communication
- ICT skills
- Interpersonal skills
- Use of foreign languages
- Entrepreneurship
- Job seeking
- Learning to learn

Most of these life skills can be attributed to soft skills. Among the proposed list, teachers had to choose the most important in their opinion. The study found that the most desirable skills to be included in school curricula were: literacy and communication for Danish, British, Romanian and Spanish teachers, ICT skills for Portuguese and Romanian respondents, interpersonal skills for British respondents, learning to learn for Danish Spanish and Portuguese teachers, use of foreign languages for Danish respondents. The most acceptable means to implement the involvement of these flexible skills in the curriculum, according to the author, are the method of case-study and role-playing games (Simona, 2015).

The World Economic Forum in 2015 highlighted the 10 most important qualities needed in 2020 for successful employment, the so-called Davos concepts (Lazorenko and Krasnenko, 2019):

1. Complex problem solving
2. Critical thinking
3. Creativity
4. People management
5. Coordinating with others
6. Emotional intelligence
7. Judgement and decision making
8. Service orientation
9. Negotiation
10. Cognitive flexibility

This list has been transformed to a shorter one, so there are four competences on it now (Lazorenko and Krasnenko, 2019):

1. Critical thinking
2. Communication
3. Creativity
4. Collaboration

Each profession requires greater development of certain soft skills. Thus, in the typical program "Methodology of teaching English" for future teachers of English, the need to create opportunities for the development of essential life skills (which corresponds to our understanding of soft skills) that transcend subject boundaries, is emphasised. According to the programme, these important skills include (Bevz et al., 2009):

1. Communication
2. Collaboration
3. Creativity
4. Critical thinking
5. Information literacy
6. Intercultural awareness
7. Problem-solving
8. Time management

As skills are different, approaches, methods and tools for their development will be different. So that the teacher could work effectively with students and help them develop the above mentioned skills, he must plan the expected results and the program of action that will help students to develop the appropriate soft skills. The use of ICT in the educational process will greatly facilitate the formation of soft skills, and at the same time students' awareness of higher education latest trends will be greatly enhanced with digital and ICT literacy. Kuybida et al. (Kuybida et al., 2019) states that the development of digital skills is one of the conditions for developing the digital market of any country, a necessary condition for successful cooperation and interaction in 'innovation ecosystems'.

Nowadays ICT play a crucial role in future foreign language teachers' soft skills development. In our research we will use such understanding of ICT – "a set of methods, production processes, software and hardware, integrated for collecting, processing, storing, transmission, demonstrating and the use of data in the interests of their users" (Shvachich et al., 2017). The notion of ICTs will be considered not only as hardware and software, but also as the more advanced scheme of (Shvachich et al., 2017):

1. Theoretical principles (concepts and laws of computer science).
2. Methods of solving problems (modeling, system analysis, system design, methods of transmission, collection, production, accumulation, storage, processing, transmission and protection of information).
3. Means for achieving tasks:
   - hardware (personal computer and its components; local and global networks, modern peripheral equipment);
   - software (system, applied, universal, special, instrumental).

Nowadays ICTs are widely used in the educational process and in many cases due to the use of ICT it has become possible to create virtual universities that do not require students to stay in the classroom, but allow them to adjust their curriculum, study outside the city or country. This surely provides more opportunities to implement a lifelong learning strategy in order to enrich people's knowledge, improve skills and abilities necessary for effective adaptation to new professional and living conditions.

The use of ICT also promotes the implementation of interactive learning within the system "teacher – computer – student" and helps primarily to develop communication skills, the ability to establish emotional contact. Interactivity is a key feature of ICT in the learning process, it contributes greatly to the implementation of other didactic qualities of ICT, such as communication, adaptability, productivity and creativity (Gurevich et al., 2012).

Thus, we see that the basic didactic qualities of ICT coincide with the basic soft skills that a person must develop to be successful in today's world.

In the educational process, ICT can act as a subject of study, as a learning tools, as a means of managing the educational process, and as a tool for managing research and scientific and methodological work (Gurevich et al., 2012). Speaking about the process of learning foreign languages and preparing for future teaching activities in the context of developing students' soft skills, ICT would be considered a learning tool, a means for managing the learning process, research and methodological work.

The pandemic of 2020 promoted the massive use of virtual classrooms and video conferencing software. They are often used now as a tools for organization classes while distance learning. Such programmes and platforms as Zoom, Google Meet, Panopto, Microsoft Teams are useful helpers for every teacher. In the context of soft skills development it is worth to mention that all of them contribute to communication skills development as well as to team-building development. Being at a distance from each other, students have a possibility to continue communication and collaboration. Teachers can use these tools to split students into groups (break-out rooms), ask them to write messages in the chat (e.g. in pairs), share a screen, video, audio or files etc. The use of software for videoconferences facilitates future teachers' new understanding of classroom management in terms of making digital classroom as close to a physical one as it is possible.

The ICT as a learning tool stands for various software, platforms, Internet sources used while learning foreign languages and obtaining competences needed for future teachers. One of the most useful foreign languages learning tools are social services in the Internet, for example, social nets, blogs, mind maps, imitators of 3D space, which are called Web 2.0 technology (Kazhan et al., 2020). All these tools allow students to communicate with native speakers of foreign languages, representatives of different cultures and nationalities, that is much more useful for learning and more effective than the study of this material with the help of coursebooks. It also promotes the development of such students' soft skills as communication skills, collaborating, negotiations, emotional intelligence, intercultural awareness and others.

Mind maps or virtual boards are a good tool to develop critical, systemic and creative thinking as well as communication skills and team-building. The term 'mind map' was proposed by Tony Buzan in 1970s and later in 2007 the first program (MindMeister) for creating visualized schemes was made (Ivanova et al., 2020). At modern stage of ICT development there is a big variety of such programmes. The most popular ones are MindMeister, Padlet, Jamboard, Miro, Coogle, Xmind, BubblUs, MindMup, Canva. These programmes can be used as auxiliary means for brainstorming to share thoughts and ideas online. Brainstorming is one of the most effective methods for critical and creative thinking development. Mind maps can also be used for creating notes while lectures and conferences as well as for planning that can greatly contribute to the development of time management skills.

For the visualization of information, graphic recording is used. Such new techniques of processing and presentation of information as scribing and sketch-noting can became a good alternative to usual notes in paper notebooks or presentation. To make a video with the help of scribing or to write a lecture with the help of sketch-noting one should analyse and choose the most important facts among the variety of information proposed by a lecturer or books and media. The future teachers should reconceptualise everything and present in the most appropriate way. All these activities train their thinking making it more creative and critical as well as training their ability to solve complex problems. Among programmes that can be used for scribing there are PowToon, GoAnimate, Sparkol Videoscribe, Animaker, apps used for sketch-noting are Paper by Fifty Three, Explain Everything, Sketchbook Express, Notability. These types of visualization are especially valuable for students participating in project-based multimedia learning.

In the context of both hard and soft skills development CLIL method will be also relevant as joint learning foreign languages and computer science has a high potential for enhancing employable teacher training (Merzlykin et al., 2018).

While considering ICT to be the means of achieving our research purposes, we studied the current situation of students' digital skills development. There are the survey results realised by a team of researchers from Bogdan Khmelnitsky Melitopol State Pedagogical University, Kherson State Maritime Academy and Dmytro Motornyi Tavria State Agrotechnological University. According to it "most of the students (40.6%) who participated in the survey would like to study using the mixed learning technology (combining online, traditional technologies and self-study), 20.8% of the students prefer studying traditionally (lectures and practical lessons in the classroom), 13.9% of the students would like to study in groups (to get the project task and work on the result), 9.9% of the students would like to study on an individual schedule, 8/9% of the students would like to study distantly, 5.9% of the students have pointed out that there is no matter what technology is used" (Voloshinov et al., 2020). The investigation took place before the pandemic. Now we know that both students and teachers faced a lot of challenges mostly associated with the lack of digital skills.

We conducted a survey among teachers and students of Bogdan Khmelnitsky Melitopol State Pedagogical University in order to learn the level of awareness of methods for soft skills development and to identify the most important skills. 10 teachers and 53 students took part in the survey. The survey was conducted by means of Google Forms. Two questionnaires with similar questions were proposed to each group.

1. Do you know what soft skills are?
2. How can you define soft skills?
3. What skills from the suggested list are important in today's professional and everyday life? (several possible answers). If necessary, add to the list.
   (a) Complex Problem Solving
   (b) Critical Thinking
   (c) Creativity
   (d) People Management
   (e) Coordinating with Others
   (f) Emotional Intelligence
   (g) Judgment and Decision making
   (h) Service Orientation
   (i) Negotiation
   (j) Cognitive Flexibility
4. What skills from the suggested list are important for a future foreign language teacher? (several possible answers). If necessary, add to the list. (The same list)
5. Have you attended trainings, seminars, webinars, which cover the topic of soft skills development?
6. What methods, techniques would you like the teachers use in the classroom to improve your soft skills? (a question for students) / What methods, techniques do you use in the classroom to develop students' soft skills? (a question for teachers)
7. What ICT would help you to improve your soft skills? (a question for students) / What ICT do you use in the classroom in order to develop students' soft skills? (a question for teachers).

The study revealed that 90% of teachers have an idea of what soft skills are, among students the figure was lower, only 47.8% answered that they know exactly what soft skills are.

Among the skills a person needs in everyday life, most teachers chose Critical Thinking (100% of respondents) and Cognitive Flexibility (80%), as well as Coordinating with Others (80%), Judgment and Decision making (70%) and Complex Problem Solving (70%).

Coordinating with Others (84.9%) was in the first place for students. Other important features in the opinion of students are Judgment and Decision making (83%) and Creativity (77.4%).

In the questions about the skills necessary for a future foreign language teacher, Creativity (90%) and Coordinating with Others (90%) are preferable from the point of view of teachers. Critical Thinking (80%) and Cognitive Flexibility are also considered by teachers to be important qualities for future teachers.

Almost similar results on this issue were obtained in a survey of students: they consider Coordinating with Others (86.8%) and Creativity (86.8%) the most useful skills for future teachers, as well as Cognitive Flexibility (69.8%) and Negotiation (52.8%).

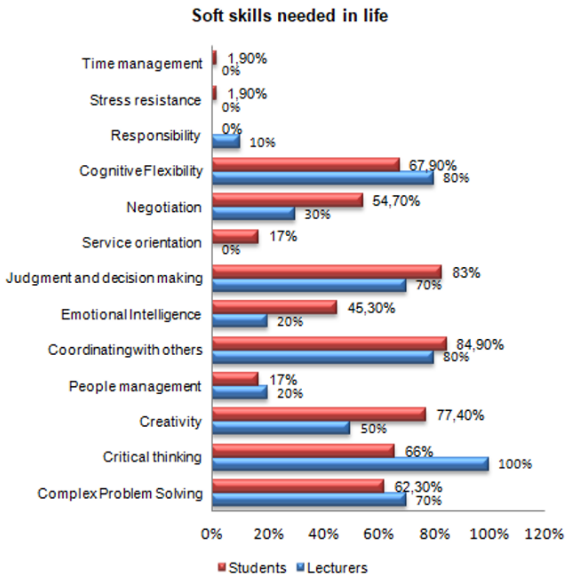

Figure 1: Students' and lecturers' attitude to soft skills needed in life.

The survey also revealed that only 40% of teachers and 17.8% of students attended trainings, seminars, webinars dedicated to the soft skills development.

Teachers demonstrated greater awareness of the methods and techniques used to develop soft skills (group work, project technology, problem-based learning, role playing game, business game, discussion, interactive communication, micro-teaching, work in variable groups). As for students, most respondents did not have a clear idea of the methods that can enhance the soft skills development. Only a few students were able to answer clearly (group work, business games, creative tasks, research projects, trainings, interactive games and technologies). However, almost all respondents mentioned methods and techniques related to creativity and active interaction between people. Some students expressed their wish to develop time management and public speaking as rather important skills.

Among ICT assisted methods and techniques used by teachers in class to develop soft skills, there are web quests, E-learning, Google Forms, Google Docs, Jamboard, audio and video materials, case method, review and analysis of Internet pages on the problem, computer testing, multimedia equipment, e-mailing, social networking, TED talks. There were some other items mentioned though they can be called neither methods nor techniques.

Many students found it difficult to answer this question. Some of them mentioned artificial intelligence, various messengers, social networks, video conferencing, viewing of developing content, information portals, mobile applications, media broadcasts, webinars, trainings, interactive quests.

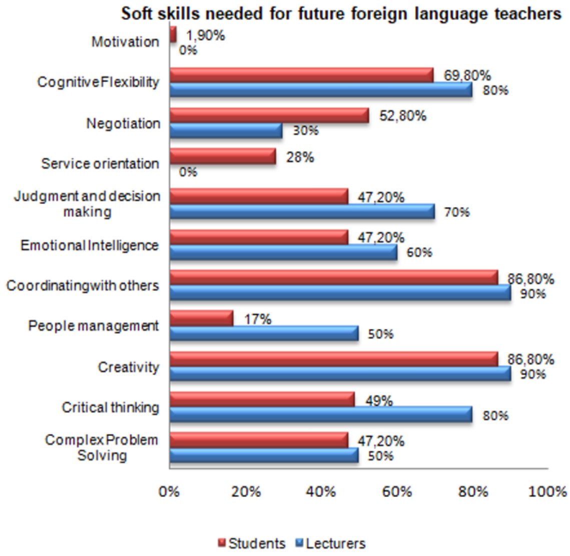

Figure 2: Students' and lecturers' attitude to soft skills needed in professional activity.

Thus, having analysed the survey data, we can conclude that both teachers and students have almost the same idea of future foreign language teacher's soft skills. Both groups of respondents replied that the focus should be made on the development of creative thinking, creativity and the ability to cooperate with others. However, we observed a lack of awareness and understanding among students about methods, techniques and tools to be used in the process of soft skills development. Thus, it is necessary to pay more attention to this issue in the educational process and to integrate soft skills development in educational programmes content and aims.

On the basis of information collected by us and mentioned above with the further study of the topic, we plan to develop a model for soft skills development of future foreign language teachers, which will be mostly associated with the use of modern ICT. It is planned to implement the developed model into the educational process of applicants for higher education of Bogdan Khmelnitsky Melitopol State Pedagogical University, who study in the specialty 014.021 Secondary education (English language and literature) and check its effectiveness.

Now on our list of soft skills to primarily develop are those offered in the typical program "Methodology of teaching English" for Bachelor's degree (Bevz et al., 2009): communication, collaboration, creativity, critical thinking, information and digital literacy, intercultural awareness, problem-solving, time management. Step-by-step, we are going to add other soft skills to this list as modern reality is extremely dynamic and requires flexibility and quick reaction to everyday challenges in education.

Among methods and technologies to be used first and foremost are the following:

1. Problem-based learning
2. Case-study method
3. Interactive learning technologies
4. Game technologies
5. Blended learning technologies and m-learning technology

In the process of implementing the soft skills development model, we will focus on classroom and distance learning within the curriculum of the study programme. Besides of activities in physical or virtual classes there will be special focus on students' self-study dealing with their learner autonomy and other skills. One more component of our model will be linked to students' extracurricular activity. For these purposes the list of recommended ICT tools will be created to support students.

Our research plan comprises the idea of creation an educational centre or a hub which will be a territory for cooperation, collaboration and sharing experience, a place for discussing issues related to methodology of teaching foreign languages and various issues related to the educational process, current trends in education, of the national and world level, small-scale and large-scale investigations. It is possible to involve not only students and teachers of Bogdan Khmelnitsky Melitopol State Pedagogical University, but also stakeholders: school teachers, methodologists, various educational and cultural organizations representatives. Other universities, schools and colleges can also be involved in the cooperation.

By participating in the educational hub, students will be able to develop such soft skills as communication skills, skills of cooperation and critical thinking, to expand their intercultural and international awareness. Participation in seminars, trainings, etc. will allow students to prepare for future professional activities and expand their understanding of modern professional requirements, combine their learning and research. A special sequence of workshops with ICT assisted professional development activities will be delivered, so that future teachers could handle with their soft skills at present and be ready for that in future.

4 CONCLUSIONS

The process of training foreign language teachers for professional activity, equipping them with hard skills cannot and should not be limited to the development of professional skills and abilities, it is also necessary to develop universal skills that will help them be more competitive in the labour market and more effective organise their professional activity. In the modern system of higher education in Ukraine, although there appear researches of the need to focus on the methods and ways to develop soft skills of representatives of various branches, but there are no effective programmes of action or models of implementing this idea. So the issue remains relevant and needs further consideration. We hope that the working out and implementation of the model of future foreign language teachers' soft skills development will be effective and help students feel more confident when starting their professional career.

There are still a lot of issues waiting for further study and finding solutions. For future employees in any branch the framework of their professional training should contain not only hard skills and competences but also be focused on creating the opportunities for their soft skills development. The list of soft skills for each job should be compiled, the recommendations of the possible ways for their development should be produced.

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EdTech Landscape in Ukraine: Smart Education Future in Digital Age

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Keywords: Digital Education, EdTech, Technological Innovation, Startup, Efficiency.

Abstract: The digitalization of education is much slower than in other areas, due to the high cost of digital solutions and their complex functionality. Recently, the situation is changing, and now education can get real benefits from technology with simple software solutions. Analysis of the effectiveness of education has shown that the countries of Europe and Central Asia have significant potential for the development of education. Technologies used in education used in Tutoring, Language learning, MOOC, School Education (K-12), STEM & coding, Robotics, Information platforms, for teachers, LMS (learning management system), IT Education, Upskilling, Tools, and Talent. These technologies provide an opportunity to improve learning processes and increase its efficiency. In 2020, the EdTech startup ecosystem of Ukraine has more than 80 startups that have been used for education. SWOT-analysis indicate that the EdTech startup ecosystem is characterized by more weaknesses and threats than strengths and opportunities. Ukrainian education has significant potential for increasing efficiency and development.

1 INTRODUCTION

The modern world is a world of technology, digitalization, and rapid change. The digitalization of education is much slower than in other areas due to the high cost of digital solutions and their complex functionality. However, COVID-19 and the lockdown caused by it significantly changed the situation in education (Nagaraju et al., 2020; Polhun et al., 2021). The growth rate of education digitalization during the pandemic has only accelerated and education can benefit significantly from technology through simple software solutions. All this contributes to the intensification of cooperation between universities, business, and science. Universities have a need for modern technologies that will promote effective communication between all participants in the educational process. Accordingly, the niche of digital solutions for education and science has grown, to which business responds by offering new products and services. The development scenarios dictated by the pandemic include a further increase in the share of online education in investment, audience reach, and the absolute number of professionals employed in it.

EdTech research and digitization in education have become widespread in recent years. Education innovation in digital era is studied in (Abad-Segura et al., 2020; Hashim, 2018; Haywood, 2018; Salem and Voskoglou, 2020; Yuliati and Lelawati, 2019). Some directions of use of innovative approaches in education are covered in (Abdel-Basset et al., 2019; Babenko et al., 2021; Dimitrov et al., 2019; Hariharasudan and Kot, 2018; Pinchuk et al., 2020; Salem, 2019; Sousa et al., 2019; Syvyi et al., 2020; Tkachuk et al., 2020; Volkova et al., 2019). Discussion on the analysis of the impact of innovations on the educational process is presented in (Kholiavko et al., 2020; Kuzminska et al., 2020; Savchenko et al., 2018; Vlasenko et al., 2021; Zhilenkova et al., 2019).

2 MATERIALS AND METHODS

In recent years, educational services are increasingly in demand. The concept of lifelong learning, which is implemented through personal and corporate education, has become widespread. In particular, companies understand that it is much cheaper to teach new

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employees than to look for a specialist who has new skills and knowledge. However, there are significant differences in the effectiveness of education in different countries. We evaluate the effectiveness of education in different countries using Data Envelopment Analysis (DEA).

According to the concept of Farrell's economic efficiency (Farrell, 1957), each set of resources (market inputs) is characterized by a maximum of production, and the actual values of market products represent the degree of achievement of this maximum. Productions that provide the maximum market output per unit of market introduction, acquire the status of "standard" and form a "productivity limit". The task of the analysis is to compare objects in terms of efficiency of their resource base and determine the distance between the enterprise and the "productivity limit". To do this, the following methods are used:

- parametric – involves the formation of the production function for production standards by methods of mathematical statistics (construction of the stochastic limit of production capacity; adjusted least squares);
- non-parametric – determine the limits of production capacity (maximum profitability in the market) for any combination of resources (Data Envelopment Analysis – DEA).

The data analysis model (DEA) was developed by Michael Farrell in 1957. Farrell (Farrell, 1957) evaluated the effectiveness of one unit of the final product with one input and one output. The advantage of the DEA method is that it allows you to define a remote function for a multi-production system and does not require specification of the type of production function or cost function (which is necessary when using parametric methods).

The criteria of efficiency in the DEA methodology are the achievement of the Pareto optimum (Pareto et al., 2007), which is determined by the maximum possible volume of production at the existing technological level and resource provision. The DEA method allows: to determine the aggregate indicator for each studied object in the framework of the use of market inputs to market issues; take into account environmental factors; not be limited to the functional form of dependence between inputs and outputs; identify priority areas for productivity growth; assess the necessary changes in market input/output indicators, which would bring the object to the limit of efficiency.

The first DEA model was developed by Charnes et al. (Charnes et al., 1978) in 1978. Further development of DEA-models is characterized by two-vector in accordance with the influence of the scale of production.

Formally, this algorithm involves solving the optimization problem:

$$\max e_0 = \frac{\sum_{j=1}^{s} u_j y_{j0}}{\sum_{i=1}^{r} V_i x_{i0}}, \tag{1}$$

$$\frac{\sum_{j=1}^{s} u_j y_{jm}}{\sum_{i=1}^{r} V_i x_{im}}, m \leq 1, n, \tag{2}$$

$$v_1, v_2, \ldots, v_r \geq 0, \tag{3}$$

$$u_1, u_2, \ldots, u_r \geq 0, \tag{4}$$

where e_0 is the efficiency of the researched enterprise; n is the number of studied objects; r is the number of objects included in the comparison range; s is the number of objects that were selected for the latter after comparison; x_{i0} – the value of the i-th market range of the studied object; y_{j0} – the j-th market type of the studied object; x_{im} – the i-th input factor of the m-th object; y_{jm} – the j-th output of the m-th object; v_i is the value of the range of different objects; u_j is a significant number of analyzed objects j.

The target function is aimed at proportionally increasing the market outputs of the studied objects to the limits of efficiency, a variant of this model is called the output-oriented model.

3 RESULTS AND DISCUSSION

3.1 Analysis of Education Efficiency

The evaluation of the effectiveness of education in Europe and Central Asia by the DEA method, where the input – Expenditure on education, output – GDP per capita (figure 1).

The results of the analysis showed that effective education (efficiency coefficient equal 1) in Greece, Italy, Ireland, and Switzerland. Norway, France, Austria, Germany, Finland, the Netherlands, and Iceland are close to the efficiency curve. That is, European countries, in general, have experience in the effective expenditure on education. As for Ukraine, the expenditure on education is extremely inefficient, a similar situation in Georgia, the Russian Federation, and Moldova (ie in the countries of the former USSR).

Employee education is the key to a company's success. That is why companies try to get highly educated employees and maintain their qualifications at

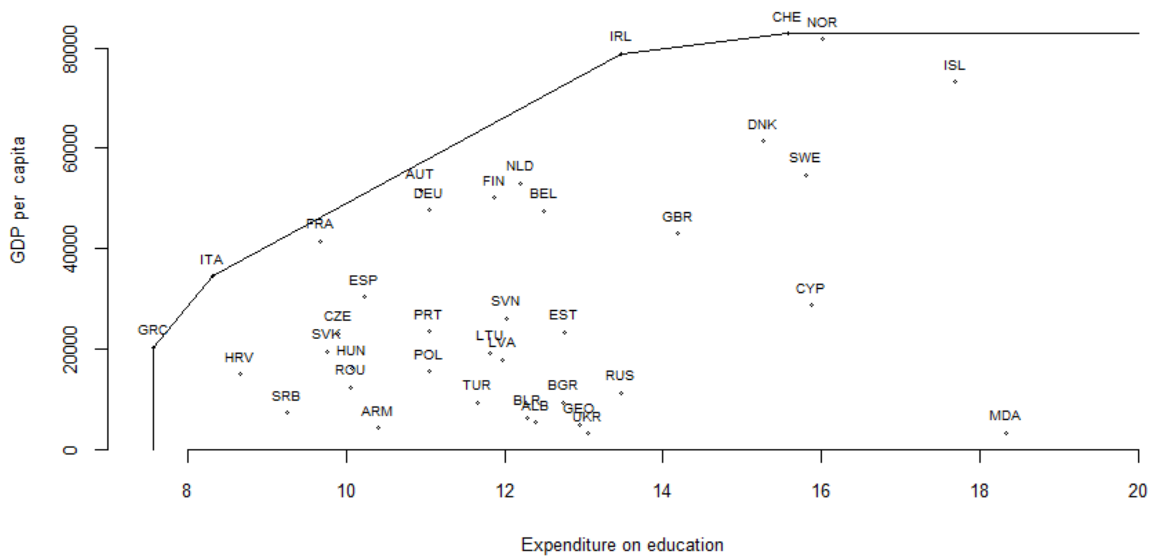

Figure 1: Data Envelopment Analysis of expenditure on education.

a high level. To assess the effectiveness of education in Europe and Central Asia, built a model of DEA, where inputs – GDP per capita, Internet users (per 100 people), Expenditure on education as (% School-age population, output – Labor force with advanced education (% of the total labor force). The simulation results are shown in the table 1.

DEA model analyzing efficiencies by VRS technology and input orientated efficiency. A number of countries with efficiency equal 1 are 21 out of 44, mean efficiency: 0.922.

The results show that efficiency is lower in those countries that incur significant expenditures on education. Conversely, countries with low spending on education have shown high efficiency. For example, Ukraine has an efficiency of 1, Labor force with advanced education – 72.15, GDP per capita - 3095.17, Internet users (per 100 people) – 89.74, Expenditure on education – 13.05, School-age population – 3.9 million. Germany, the efficiency of which is 0.72, has Labor force with advanced education – 73.56, GDP per capita – 47603, Internet users (per 100 people) – 71.13, Expenditure on education – 11.04, School-age population – 2.5 mln.

Analysis of education efficiency in different countries has shown that there is great potential for productivity increases. Therefore, the implementation of innovations in education is promising.

3.2 Investing in Educational Startups

Holon IQ is an international analytical agency founded in 2018 (HolonIQ, 2018). Initially, the company invested in educational startups but switched to market analysis to help more projects. According to the Holon IQ estimates (figure 2), global education venture capital funding in 2020 increased to $16.1 billion, which is more than twice that in 2019. Logically, this is a direct consequence of the COVID-19 pandemic and the quarantine that forced everyone around the world to go online. In the context of expected changes in the structure of the labor market, EdTech tools will continue to be in demand for the acquisition of new skills and retraining of employees. Note that China invests the most in educational programs, for example, US funding is 2 times less than China, and European funding is 10 times less (in total for the last 10 years).

Global EdTech started the last decade with $500m of Venture Capital invested in 2010 and finished 32x higher at $16.1B in 2020, nearly 2x the previous investment record in 2018.

If we talk about the structure of venture financing of educational projects, the largest share falls on corporate education, slightly less on school, and only 16% on higher education (figure 3).

HolonIQ listed the 100 best EdTech companies in Eastern Europe, where 11 projects from Ukraine are included. The rating is based in:

- companies market positions;
- demand and quality of products;
- financial stability;
- attractiveness for investment;
- development progress and dynamics;
- project team.

Table 1: Data Envelopment Analysis of education effectiveness.

Efficiencies range	Number of countries	%	Countries
$0.7 \leq E < 0.8$	5	11.4	Belgium, Denmark, Germany, Netherlands, United Kingdom
$0.8 \leq E < 0.9$	10	22.7	Austria, Czech Republic, Finland, France, Ireland, Norway, Russian Federation, Spain, Sweden, Switzerland
$0.9 \leq E < 1$	8	18.2	Albania, Belarus, Bulgaria, Hungary, Italy, Poland, Slovak Republic, Slovenia
$E = 1$	21	47.7	Croatia, Cyprus, Estonia, Georgia, Greece, Iceland, Latvia, Lithuania, Luxembourg, Moldova, Portugal, Romania, Serbia, Turkey, Ukraine

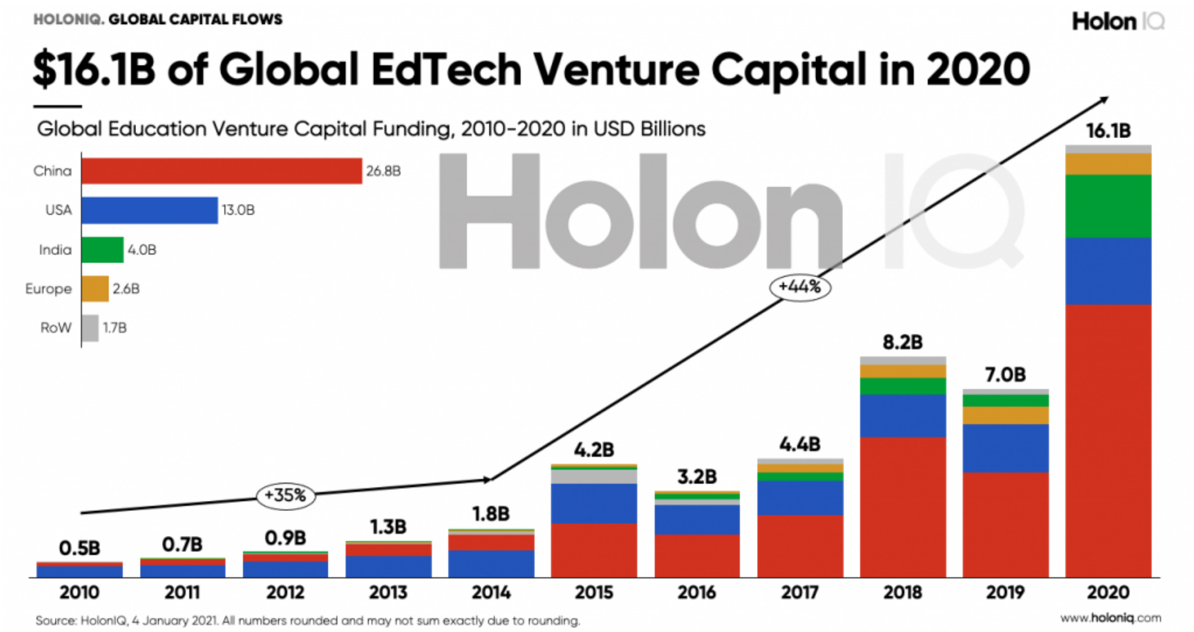

Figure 2: Global education venture capital funding, 2010–2020 in USD Billions (HolonIQ, 2021).

Ukrainian EdTech projects listed in the HolonIQ rating:

- Basenji Apps – applications for English learning;
- EnglishDom – online school of English learning;
- Enguide – service for choosing English courses in Kyiv;
- Speechyard – service for learning English by movies;
- Besmart – preparation courses for final exams at school;
- SkillUp – training courses for IT specialists;
- Skyworker – service for finding IT vacancies;
- Jooble – job search service;
- Parta – educational portal;
- Studway – media about education;
- Vseosvita – service for continuing education.

As we can see, the most popular are services for learning English. But there are nearly 80 digital education projects in the Ukrainian EdTech landscape. EdTech Landscape map of Ukraine (figure 4) was proposed by Vadym Synzheretskyi (CEO and co-founder of BUKI online platform for tutors).

3.3 Ukraine EdTech Ecosystems Analysis

Synzheretskyi (Synzheretskyi, 2020) proposed to cluster EdTech ecosystem of Ukraine in such a way: Tutoring; Language learning; MOOC; School Education (K-12); STEM & coding, Robotics; Information platforms; For teachers; LMS (learning management system); IT Education; Upskilling; Tools; Tal-

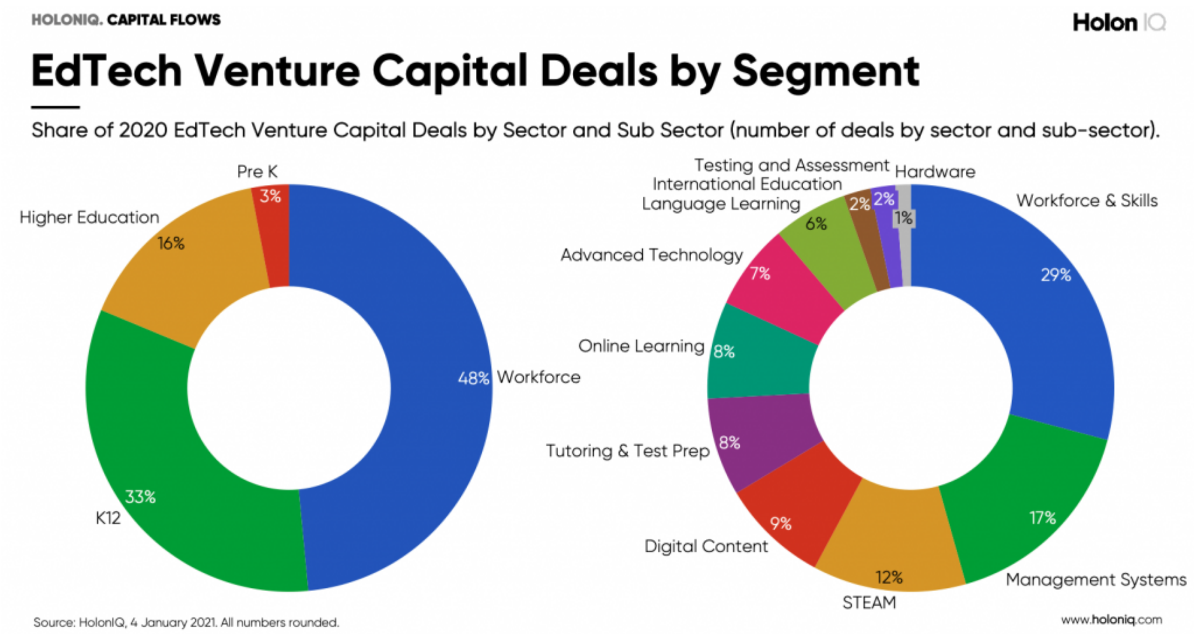

Figure 3: EdTech Venture capital deals by Segment (HolonIQ, 2021).

ent. Let's look at the examples from each group.

Preply (Preply, 2021) is an online educational platform that connects tutors and teachers (from 185 countries) with students, locally or virtually via Skype. In March 2020, the Ukrainian EdTech marketplace for the study of foreign languages Preply got $ 10 million, almost twice the amount of all previous investments ($ 5.6 million). The service uses machine learning algorithms to match tutors. The company plans to launch new tools for teachers that will help assess homework, monitor progress, and help students more effectively. The company also plans to develop a mobile application for Android and iOS.

EnglishDom (EnglishDom, 2021) is an online English school and at the same time an IT company that inspires to learn English through technology. The company is one of the leaders in the field of EdTech in Eastern Europe. The EnglishDom platform includes 5 innovative services for learning English, including mobile applications and an interactive digital textbook. The service unites more than 500 English teachers and 50,000 users.

Prometheus (Prometheus, 2021) is a mass online courses platform called "Ukrainian Coursera". The main goal of the project is to provide free online access to university-level courses to anyone, as well as to provide opportunities to publish and distribute such courses to leading professors, universities, and companies. Upon completion of the course, the student receives a certificate signed by the best teachers of Ukrainian universities. Today the platform has more than 300 thousand active users. Prometheus has organized its free online in-service training courses for educators in accordance with the requirements of the Procedure for in-service training of pedagogical and research and teaching staff. Prometheus online course certificates for educators can be officially credited as advanced training.

EdPro (EdPro, 2021) is one of the few Edtech solutions for school education. This interactive panel can replace several objects in the classroom at once – a blackboard, a projector, an interactive screen, and a computer. In such panels, teachers can show students presentations, videos, graphics, or images during lessons. Instead, students can solve learning tasks, count, or edit texts right away. Along with the board, they also developed an interactive software solution for education with illustrations and animations. Apparently, the next interesting area of EdTech will be the use of augmented and virtual reality technologies. The development of this area will lead to the fact that students will increasingly move from passive to active learning and will be able to interact in real-time with educational material, which will stimulate their motivation and increase the level of interest. This opens up exciting prospects for teaching new generations.

Osvitoria (osvitoria.org, 2021) propose interesting and up-to-date news about modern education and stories on how to change the system of education in any conditions and become a better version of yourself every day. They create a user-friendly platform for teachers and parents to help them find answers to

Figure 4: EdTech Landscape of Ukraine (Gritcyk, 2020).

their children's education and upbringing and to involve parents in the learning process. They try to give teachers effective tools for communication, the opportunity to learn about the best practices of teaching abroad, the latest news on education reform.

In addition to quality analytics, there are many different selections, articles about the needs of students and teachers with options for proposals that can be done in a particular situation. Teachers can take great advice to improve their work, and parents – to improve the well-being or performance of their children.

The educational project **Na Urok** (naurok.com.ua, 2021) aims to objectively cover the modern educational process and bring it to a qualitatively new level. This became possible due to the implementation of versatile and thorough work: writing informative articles related to school and extracurricular life; conducting thematic webinars; introduction of various educational competitions; attracting the best developments in school subjects from teachers from all over Ukraine. The project aims to help teachers feel their own significance because each teacher in the project

Table 2: Comparative study of the EdTech projects.

EdTech project	Type	Advantages	Disadvantages
Preply	Tutoring	Reaching a large audience. The use of machine learning in management.	Communication local or Skype. Absents of mobile applications.
EnglishDom	Language learning	Use innovative services and mobile applications. Reaching a large audience.	Lack of offline support.
Prometheus	MOOC	Use mobile applications. Reaching a large audience.	The audience is limited to Ukrainian-speaking users.
EdPro	School Education	Use innovation technologies. Good motivation for students. Opportunities for different applications.	High cost of the product
Osvitoria. Media	LMS	A large amount of information about various aspects of the educational process	Lack of mobile application
Na Urok	Information platforms	A good motivational approach. Coverage of a large number of educational topics.	No mobile application. A small audience of parents and students.
eTutorium	For teachers	A successful solution for organizing online learning. Great prospects for further development.	Having strong competitors with free solutions.
Mate academy	IT Education	Opportunities to expand the audience. Large set of programming courses.	Risks of non-payment for training.
Grammarly	Tools	Ease of use. Wide audience of users. Constant demand for products.	English spelling only.

will be able to publish their own professional achievements or use the work of colleagues. The project is set up to work closely with educators who want to share their experiences on the Internet. The Na Urok team makes a significant effort to ensure that teachers, parents, and students can find the maximum amount of useful theoretical and practical materials for the school on the portal.

The **eTutorium** (eTutorium, 2021) project aims to organize distance learning through the implementation of effective IT solutions. The project arose in 2008 from attempts to create their own webinar platform to conduct online events. After analyzing the needs of the eLearning market, in 2010 the team moved on to developing solutions for online tutors. Today, the platform hosts between 3,200 and 5,000 webinars per month. In 2015, we launched the eTutorium project, combining an updated platform for eTutorium Webinars and eTutor Academy – the Academy of Tutors, where we share our experience and knowledge in the field of online learning. In 2019, they created eTutorium LMS – a system of distance learning, with which you can not only collect courses but also fully organize the learning process online.

Mate academy (Mate academy, 2021) is an online platform for learning programming and finding your first job in IT. The training lasts 4-5 months and takes place online. Now in the portfolio of Mate academy courses includes Java, Front-end, Full Stack Web, UI / UX Design. The peculiarity of the platform is that students pay for their studies only in case of employment, giving a percentage of the new salary. During the existence of Mate academy, more than 200 students got jobs. In 2020 the company was planning to open a business in new markets; They looked at the country, where there is a great demand for engineers and the road, for no worse than the knowledge. The aim of the company in 2022 there were a number of thousands of engineers in Ukraine and the English regions – for example, Great Britain and India.

Grammarly (Grammarly, 2021) is one of the most famous Ukrainian startups. This is a service for checking written texts. It helps to correct grammatical and stylistic errors. A free version is available, as

Table 3: SWOT analysis on EdTech system.

INTERNAL FACTORS	
Strengths	**Weakness**
The government starts to implement digital technology in education. There is a demand for digital education and innovative technologies in education from both business and private. Effective solutions that promise an increase in productivity	The high cost of innovative technologies. Problems with finding financing. The delayed effect of digital technologies implementation can decrease the effect of its realization. Unreadiness for change. The established habits of teachers and the lack of new skills and abilities. Bureaucratic hurdles for starting a business. Underdeveloped IT infrastructure Lack of information on the effectiveness of EdTech.
EXTERNAL FACTORS	
Opportunities	**Threats**
Education is a big area with a lot of students and pupils, which can demand many EdTech projects. The application of EdTech produces a lot of data that can be used for agriculture development. EdTech can significantly reduce the need for teachers and administrated staff.	If the EdTech is not reliable enough and accessible to attackers, the danger may arise for education. The probability of different EdTech results in different conditions. Access to data can increase inequalities, impede competition, and create economic barriers.

well as Premium, which expands access to additional features. The company's head office is now located in Silicon Valley, and the service was founded by three Ukrainians. In 2019, it became known that the total amount of investment in Grammarly is about $ 200 million (5 billion hryvnias). This funding has raised the company's total value to more than $ 1 billion. So from now on the Ukrainian startup can be officially called a "unicorn". Grammarly services are now used by millions of regular users around the world. We are talking only about English-speaking users, the developers do not plan to expand the number of languages for testing yet. As of 2020, 30 million people use Grammarly services every day.

3.4 SWOT Analysis on EdTech System of Ukraine

The key task of education in modern conditions is to change, adapt to new conditions, and develop. The analog world is becoming increasingly fragile, and the digital world is becoming antifragile. COVID-19 not only posed threats to agriculture but also opened up new opportunities, in particular in digitalization and the introduction of innovative technologies. In our opinion, education in Ukraine needs the introduction of a significant number of EdTech, which will accelerate the development of education and increase its efficiency. SWOT analysis of the EdTech startup ecosystem is presented in table 3.

4 CONCLUSION AND FUTURE WORK

Nowadays education needs to improve and increase efficiency. EdTech can become exactly the direction that will promote the active development of education, increase its accessibility and improve its quality. Analysis of the effectiveness of education has shown that the countries of Europe and Central Asia have significant potential for the development of education.

The EdTech startup ecosystem is characterized by more weaknesses and threats than strengths and opportunities. Ukrainian education has significant potential for increasing efficiency and development. To ensure the realization of this potential, it is necessary to do the following:

- increase government spending on education, in particular on the development of innovative technologies;
- ensure access of EdTech to financing;
- accelerate the process of digitalization of education, in particular, to promote the spread of affordable ICT and introduce e-government;
- increase the interest of non-governmental organizations in the introduction of innovative technolo-

gies in education;

- create favorable conditions for the development of EdTech ecosystems.

Further development of the EdTech startup ecosystem can be a key solution for the development not only in Ukraine but also around the world.

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Moodle Tools for Educational Analytics of the Use of Electronic Resources of the University's Portal

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Keywords: E-Learning, Learning Management Systems, Educational Analytics, E-Course, Analytics Tools CLMS, Moodle, Higher Education.

Abstract: The need for additional analysis of the effectiveness of e-learning implementation models and their resource support in higher education institutions in the context of the COVID-19 pandemic has been actualized. An overview of solutions and case studies in the context of selecting and analyzing the effectiveness of individual services and learning management platforms is provided. It has been studied that in order to investigate the effectiveness of using electronic resources to meet students' educational needs, it is advisable to use quantitative indicators in addition to student description results. This includes data from educational analytics on the frequency and duration of students' use of individual e-resources. Reviewed the functionality modules "Course Comparison" of the Moodle LMS and "Statistics", as well as the optional Analytics module. The results of applying these modules to the analysis of e-learning courses of the National University of Life and Environmental Sciences of Ukraine and Boris Grinchenko Kyiv University are presented. The reasons for students' low use of individual e-courses were investigated.

1 INTRODUCTION

The issue of the quality of e-learning resources in a distance learning environment is extremely relevant during the quarantine period associated with COVID-19 (Vakaliuk et al., 2021). Despite the various quality assurance procedures for e-learning resources for students, especially in forced distance learning settings, it is often very difficult to assess the quality of the resources used relying on these procedures, which mainly include student surveys and peer review. However, due to the transition of higher education institutions to distance learning (Bobyliev and Vihrova, 2021) and in the context of the pandemic generated by COVID-19, the problem of analyzing the quality and adapting the design models of educational environments (Morze et al., 2013; Glazunova and Shyshkina, 2018), according to the types of institutions, educational program, available resources, has become more relevant and other (Edelhauser and Lupu-Dima, 2020).

Looking at e-learning quality indicators from 2000 to 2017, Silva et al. (Silva et al., 2018), based on an analysis of scientific publications, identifies that indicators that have the greatest weight can be grouped into three categories: e-resources, data, processes. In the context of this study, we can look at the same resource provision with a focus on practical cases and a combination of quantitative and qualitative assessment.

For example, in distance learning for future health professionals, digital imaging should be used extremely closely to real-life practice. Educational institutions use specialized software, e.g. Clinical Study Export (TCE) as a platform for extending the PACS infrastructure by connecting educational func-

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tions (Mildenberger et al., 2011).

Understanding the importance of communication and cooperation in the implementation of distance learning, the effectiveness of the use of different services is the subject of analysis. For example, Biasutti (Biasutti, 2017) presents the results of a comparative analysis of forums and wikis as tools for online collaborative learning. However, as each service has to be seen in the context of student training requirements and educational goals, more and more researchers are looking at integrated solutions to support self-regulated educational strategies (Kraleva et al., 2019).

In this context, among the various learning Management Systems (LMS) on the market (Basaran and Mohammed, 2020), LMS Moodle is the most popular in the implementation of distance and blended learning in higher education (Oguguo et al., 2021; Mintii, 2020; Abdula et al., 2020). According to research by scientists from different countries, technological satisfaction about Moodle in higher education is quite high – the effect is equal to 0.78 with a 95% confidence interval from 0.72 to 0.84 (García-Murillo et al., 2020). The transition to distance learning and increasing the frequency of interaction between teachers and students through LMS has necessitated the search for resources to bring online communication closer to offline. One such solution is Moodle LMS integration with Amazon Alexa for creating voice content (Ochoa-Orihuel et al., 2020).

On the other hand, the success of a distance education program can be assessed, in addition to academic performance, by the level of student satisfaction. However, there is a correlation between student satisfaction with e-courses (e-resources and content) and readiness for online learning (Deveci Topal, 2016). The latter is usually determined by surveying students, and is checked – by data of educational analytics which allow to analyze behavior of students in LMS (Kadoić and Oreški, 2018). Since the use of educational analytics or analytics for student success, according to Brown et al. (Brown et al., 2020) is identified as one of the areas of educational technology, we consider it appropriate to use educational analytics to determine the causes of student satisfaction / dissatisfaction, followed by recommendations for improving resources and methodological support its application in higher education institutions. To do this, it is necessary to explore the tools that can be used to quickly analyze the effectiveness of resource use, in particular, e-learning courses in disciplines, and relevant indicators. Such analysis will allow a rapid response to the problems that users of e-courses are experiencing, allow for quick resolution of these problems and make student learning more productive.

Research goal: justify the choice of tools for educational analytics on the use of e-learning courses, in particular to determine user activity, frequency and duration of use of course resources in order to recommend to teachers to improve the quality of both course materials and methods of using relevant resources during distance learning.

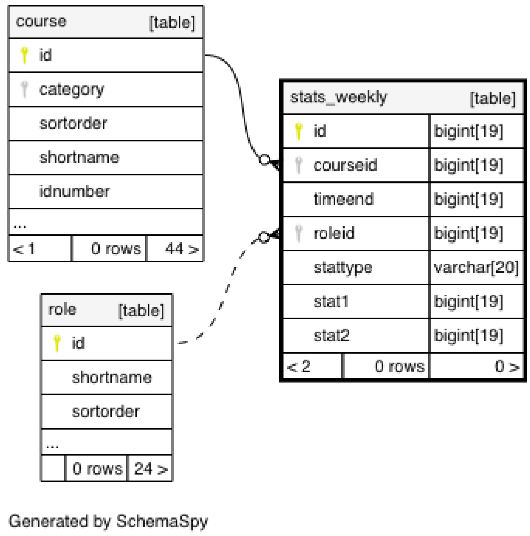


Figure 1: Moodle e-course comparison module data model.

2 METHODS AND STUDY MATERIALS

The study was conducted using data from the training portal of National University of Life and Environmental Sciences of Ukraine (NULES) and Borys Grinchenko Kyiv University (BGKU). Methods and technologies of statistical analysis were used for the research.

The university's learning portal usually operates on the basis of CLMS (Content Learning Management System) platforms and is designed to support the learning process with e-resources in the format of e-books, web pages, lessons and video lessons, test tasks, laboratory and practical, independent work. For each discipline in the e-learning course can be placed the above and other resources. It should be noted that the use of e-learning courses in the educational process should correspond to the working curriculum of the discipline, and the resources should contain relevant, popular information. The procedure for attestation of electronic courses in universities involves the implementation of a number of criteria, which are usually spelled out in the relevant regulations. In particular, in NULES, these criteria are divided into structural-functional, scientific-substantive and methodological. But the use of certified courses is not uniform throughout the semester. At the same time, students actively use part of the resources in the courses, and some resources are not used at all. In order to identify the reasons for this and to select tools for quick analysis of course performance data and its resources, it is necessary to analyze the relevant tools, which are built-in or complementary.

Let us focus on the statistical and analytical tools of CLMS Moodle. Course resource efficiency indicators can be obtained through the use of the embedded modules: “Course Comparison” and “Statistics” modules, as well as the optional “Analytics” module.

2.1 Features of the Module “Comparison of Courses”

The analysis modules in the base Moodle distribution are not very powerful, but they are present too. One of the first modules that is appropriate to use when analyzing courses is Course Comparison. This can be found under Manage – Site Management – Reports. This module allows you to view four reports:

1. The most active courses (ranks courses by the number of actions taken by their participants as a whole).
2. Most active courses (weighted) (calculates the average performance per user in the course).
3. Participation rate (shows courses in descending order of user participation rate).
4. Activity ratio (determined by the ratio of involvement and participation of users in the course).

Some of these concepts need clarification.

The first analytical report gives us the opportunity to see on which course there is active activity. Activity on a course is the total number of all views and publications on the course during the period under study. However, this is of little use as a large number of enrolled users will visually create more activity compared to courses with a relatively small number of participants.

Consequently, a weighted average of each user’s activity on the course is already more informative and will show everyone’s participation. Here you can see how truly active courses with a small number of users come to the fore. However, if there are few active users on the course, the mass of enrolled but inactive users will drag the course down in the rankings.

The following report can clarify this nuance. It shows how many real active students are on the course. The participation rate of active users is calculated as the share of active users to the total enrolment in the course. Active users are defined as those who had had activity during the period under study. But here again the question arises, what are these users doing on the course? Are they just reading (receiving information) or are they active?

The fourth report gives us the answer to this question. The publication and views activity ratio is calculated as the share of publications in relation to views. Where views refer to any user going to another page and ’reading’ it or downloading a file resource from the course to their computer. Publications are defined as any activity the user performs on a course, for example, completing a quiz, completing a task (downloading a file or writing a text response), replying to a forum post, and so on. That is publishing is not just a forum post.

2.2 Features of the “Statistics” Module

Another auxiliary module for analyzing course performance is the Statistics module, which operates at the site level, providing some statistics on the activity on courses as a whole, as well as in each individual course. At the site level, the results of this module are available to administrators and site managers. At the level of each course, teachers can use it to generate statistics within that course.

About the Course Comparison module analyzing activities without dividing into teachers and students, it is important to say exactly who generates such activities – the actual training of students or the active creation of a teaching course by teachers. The Statistics module brings clarification. Using this module, we can see the activities of each individual role. It is also possible to look separately at views, only publications, or only introductions. At a site-wide level, these metrics plot all roles, while at a course level we can get a separate graph for each role.

2.3 Possibilities of the “Analytics” Module

Additional analytical reports can be obtained using third-party modules. One such powerful addition is the Analytics module. With its help it is possible to analyze activity of each student both as a whole on a course, and in each concrete resource of a course. We are provided with such reports:

- Valuation chart (shows the distribution of valuations using a stock chart)
- Work with content (shows the activities of stu-

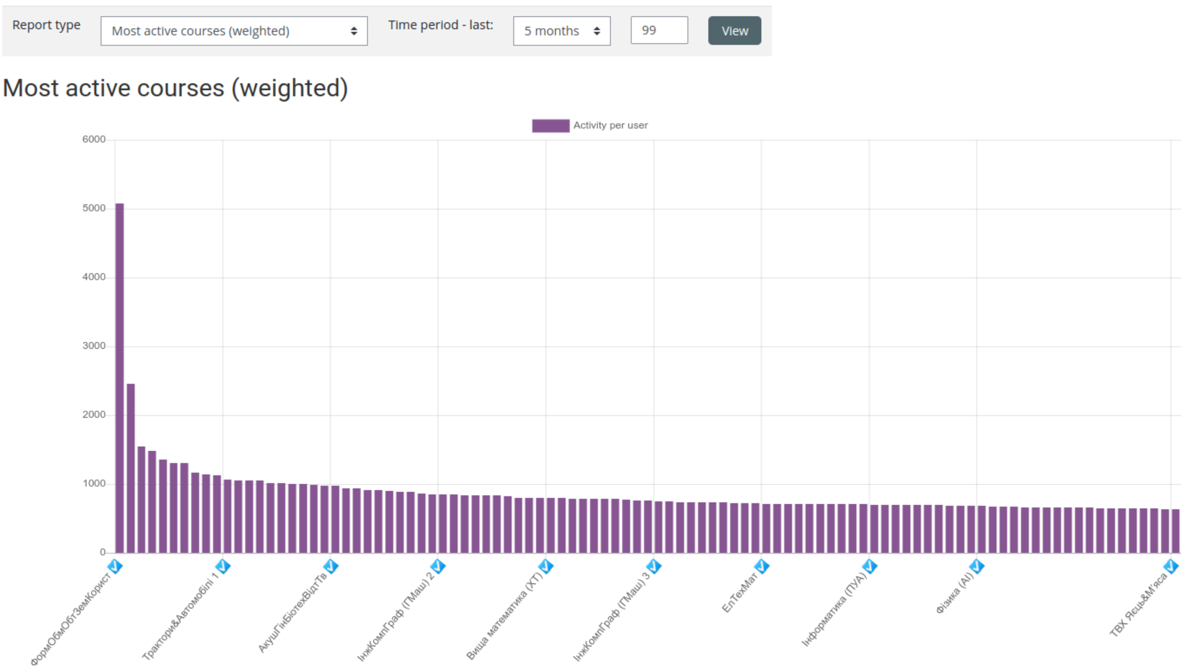


Figure 2: Courses usage statistics.

dents with each resource separately – how much they worked and how much they ignored)

- Student activity (shows a consolidated distribution of student activities on the course in terms of hours per day)
- Execution of tasks (shows a diagram for all Tasks, which demonstrates compliance with the deadlines)
- Passing tests (shows a diagram for all tests, which demonstrates compliance with the deadlines)
- Distribution of views (shows the schedule of personal activities on the course of each student)

3 MAIN FINDINGS

Only certified electronic learning courses (ELC) were chosen for the study, i.e. courses in which the structure and set of resources are correctly selected for the implementation of the educational process. Thus in NULES the certified courses operate within 5 years, and in BGKU – within 1 year. The number of certified courses at the end of 2020 in NULES was 1644 courses, in BGKU – 768 courses.

The first hundred most active courses (with high average activity per user) can be obtained by using the Course Comparison module and its "active courses (weighted)" report (figure 2).

Based on the results (figure 2) it is possible to identify courses with low user activity. The following analysis of the content of such courses, didactic features of the use of course resources will make it possible to identify relevant problems with their use.

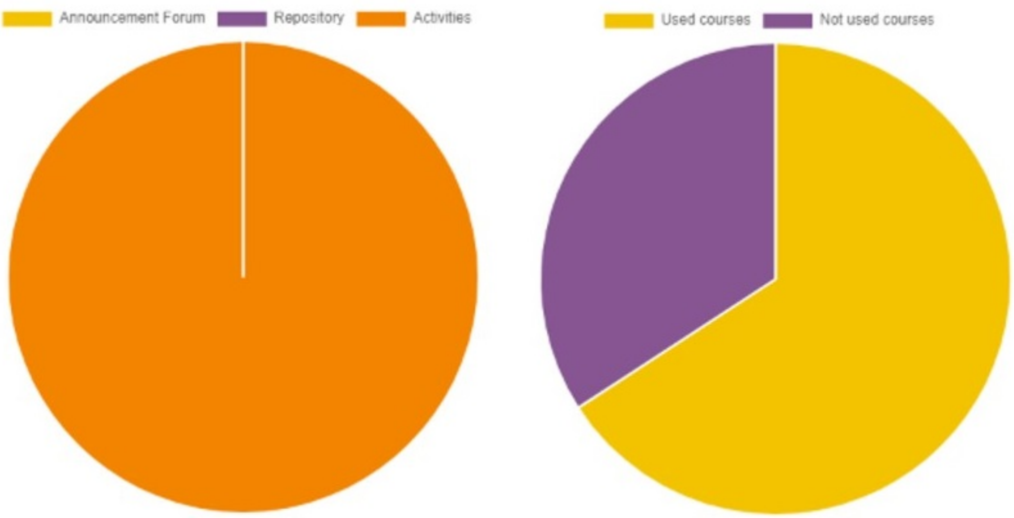
Usage statistics courses and the way they use within the categories are also using the module "Statistics". For example, in BGKU such statistics can be obtained by categories of departments (figure 3), and in NULES – by categories of specialties.

A direct query to the database of courses makes it possible to obtain such data for all certified courses.

As a result, all courses can be divided into 3 categories: courses with low efficiency, sufficient and high in terms of "activity per user". For example, NULES with a high degree of use has 12% of certified ELC, with sufficient – 57%, with low – 31%.

Analyzing ELCs with high efficiency, a number of studies have been conducted on the use of resources of these ELCs using an analytical module built into Moodle.

For example, figure 4 reflects the students' activity in the course "Computer Technologies and Programming" during the last semester. The activity of students in revising resources and publishing completed tasks or passing tests is uneven. The peak falls towards the mid-term examinations and the end of the semester, which may explain the need to complete the quizzes. But we can conclude that the use of the course at the beginning of the module is not



Amount of created courses	Used courses	Not used courses
158	104 (65.82%)	54 (34.18%)

Usage type	Amount of courses	% per used courses	% per created courses	Description
Announcement Forum	0	0.00%	0.00%	The course is being used only for communication by means of the **Announcements Forum**.
Repository	0	0.00%	0.00%	The course is being used only as a file repository. That is, the teacher has created just **File**, **Folder** or **URL** modules in this course.
Activities	104	100.00%	65.82%	The course is being effectively used. That is, the teacher has created exciting modules types such as **Forum**, **Quiz**, **Assignments**, **Questionnaries**, among other in this course.

Figure 3: Courses usage statistics by category.

active enough and indicates that the laboratory and self-study assignments are not completed on time and, consequently, students are not working with the resources.

To find out with which resources in e-courses, students work actively, the function “Working with content” of the module “Analytics” is used. For example, figure 5 shows the activity of using theoretical resources of the course “Information Technology”. From this diagram we can conclude about the extremely low activity of students in the use of theoretical resources, in contrast to laboratory work.

Often students actively use electronic learning resources in a discipline only because they have to take a test every day and hand in work to be tested, but they do not use theoretical resources because they are not very informative. Another option is for students to actively use methodological materials in the discipline, watching video tutorials, and to a lesser extent use resources designed to monitor learning achievements. An important task for universities is to obtain tools to quickly assess the quality of electronic resources by further using their content and methodology in the teaching process.

Next, you need to analyze the content of educational material set out in theoretical resources, in terms of structure, accessibility, relevance, practical orientation. These are all tasks of scientific and substantive examination. Such an electronic course can be reconsidered by the educational and methodical commissions of the faculties regarding the possibility of its use in the educational process.

As a result of using such tools, we have the opportunity to determine which e-courses contain:

- an excessive number of tasks (exceeding the number of laboratory, modular and independent tasks)

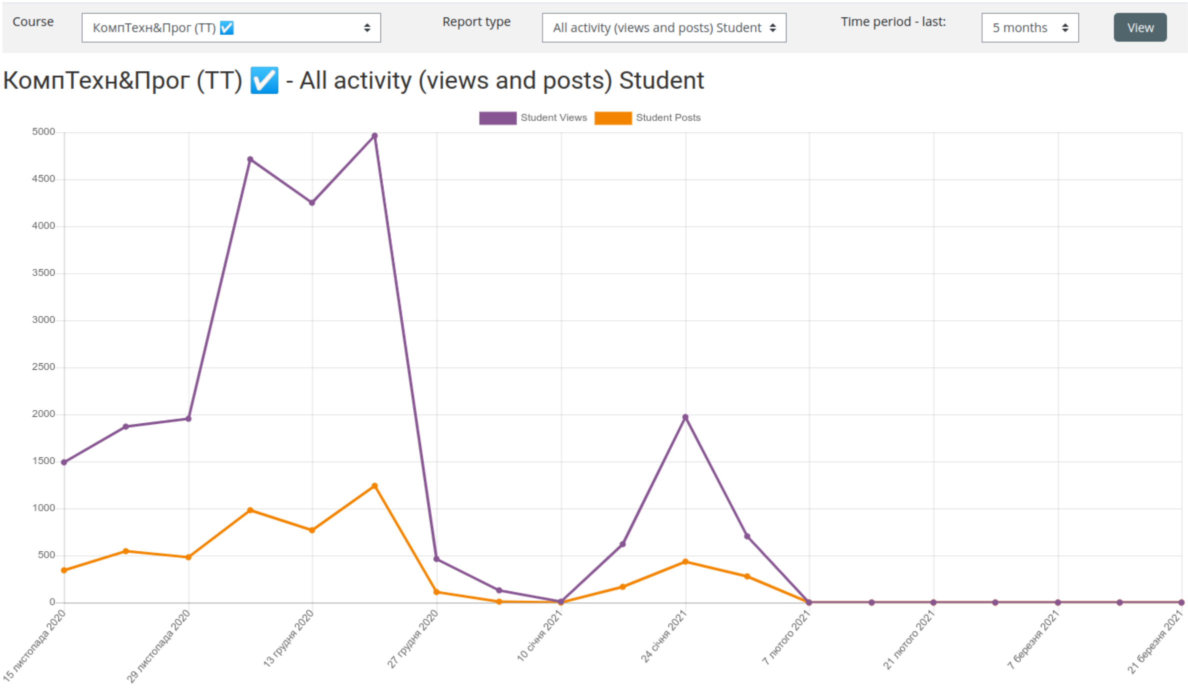


Figure 4: Analysis of electronic courses on the subject of general activity of students.

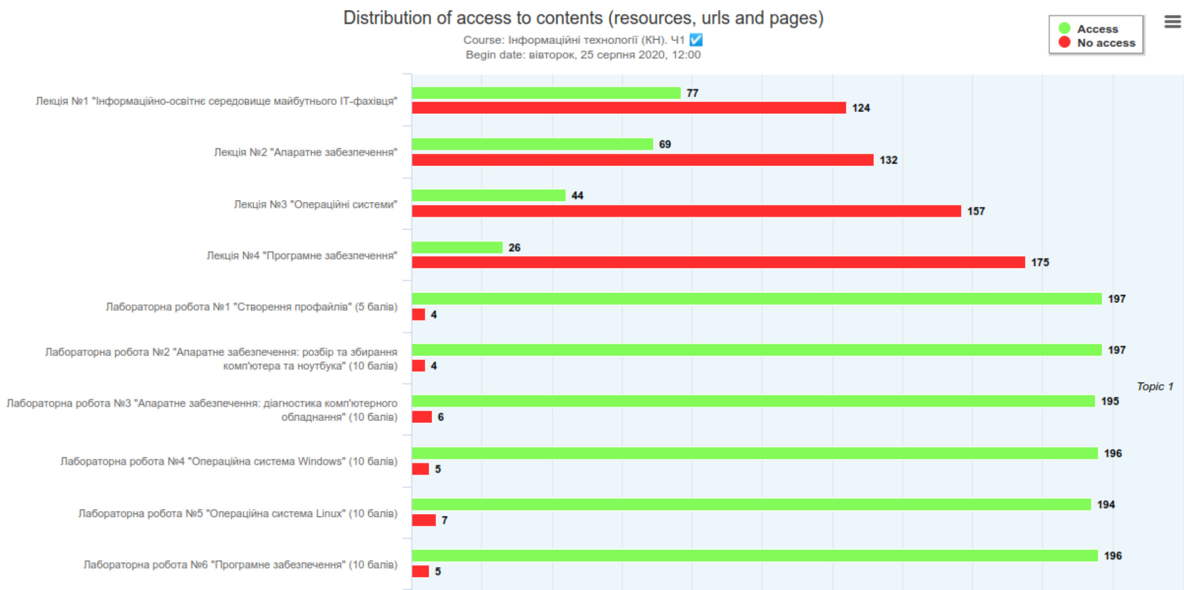


Figure 5: Analysis of e-courses on the use of resources.

that required the work of students with the course;

- little informative, unstructured training materials
- qualitatively presented theoretical materials and methodical recommendations, which were actively used by students;
- educational resources that were systematically used during the semester.

To increase the efficiency of the use of ELC in higher education, a number of steps can be taken to use statistical and analytical tools Moodle (figure 6).

The first step should be to rank the courses by activity per 1 user (weighted indicator). For all courses that are actively used, the second step is performed – statistics of general activity in e-courses and analytics of resource use in e-courses. The third step is to form

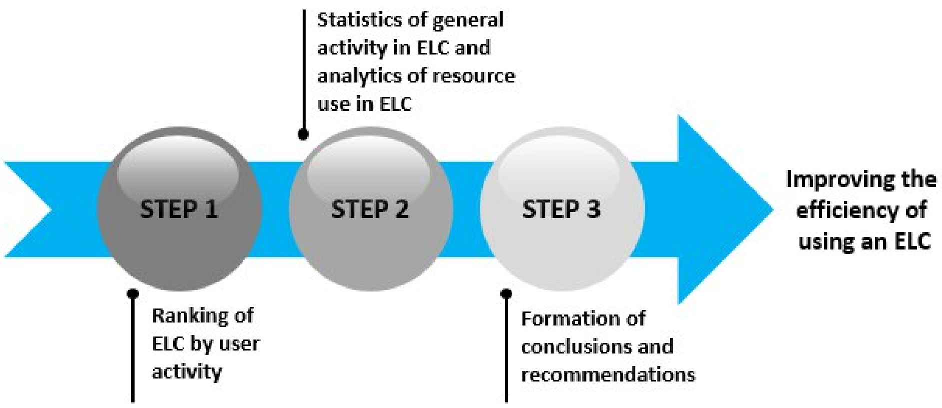


Figure 6: Scheme of using statistical and analytical tools Moodle to increase the efficiency of ELC.

conclusions and recommendations.

Identifying e-courses that are insufficiently used in the educational process, provides an opportunity to intensify work with teachers to improve their skills with information support, to create e-courses, the use of e-resources in the educational process. The e-resources found not to be used by students in the learning process should be reviewed according to scientific peer review criteria. Built-in and additional CLMS Moodle tools allow you to analyze the effectiveness of e-courses in general and in terms of different types of resources and, based on this analysis, to form general recommendations for course teachers to improve the use of e-courses in education.

4 CONCLUSIONS AND THE RESEARCH PERSPECTIVE

The use of statistical and analytical tools in CLMS Moodle to determine the effectiveness of the use of e-courses contributes to the quality of the educational process, in particular blended and distance learning. By measuring weighted course user activity, overall activity within the course and analyzing the use of course resources, it is possible to identify the reasons for the inefficient use of e-courses in the educational process. Since the study was carried out on the basis of two higher education institutions, we can assert general trends on the problems of using e-courses in blended and distance learning. In the future, we see the need to develop a model that provides automated determination of levels of effectiveness of e-courses, e-course resources, identification of factors that affect the effectiveness of the use of courses, and specific resources.

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Integrated Use of the LearningApps.org Resourse and Information Devices in the Process of Biology School Course Studying

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Abstract: This paper considers the problem of integrated use of the LearningApps.org online resource in the process of Biology studying in secondary schools and information devices. The appropriateness of moving to a mixed form of learning that involves the creation of a polysubjective educational environment has been justified. The article concretizes the essence of the notion "polysubjective educational environment" (teacher, pupil, online resources, and information devices). It has been examined how well the scientific problem is developed in pedagogical theory and educational practice. The methodology of using the LearningApps.org online resource in the process of Biology studying in a basic secondary school, which involves the use of information devices, the PlayMarket server applications, Smart technologies and a website has been created. In particular, a series of exercises of the LearningApps.org online resource has been simulated, the implementation of which should be integrated using a SMART Board, a mobile phone, a computer, a laptop, a tablet or other information devices. Possibilities of their combination with the methodology of using information devices at the lesson in the process of homework checking, learning new material, generalization and systematization of knowledge have been revealed. The proposed assignments can be used as individual exercises for pupils at the lesson and in extracurricular activities. The paper suggests the approach for homework checking, which involves besides computer control of pupils' learning outcomes, the use of Miracast wireless technology. The methodology of conducting a mobile front-line survey at the lesson on the learned or current material in Biology in the test form, with the help of the free Plickers application, has been presented. The expediency of using the website builder Ucoz.ru for creation of a training website in Biology has been substantiated. The methodology of organizing the educational process in Biology in a basic secondary school using the training website has been developed. The effectiveness of the proposed methodology of using the LearningApps.org online resource in combination with information devices in the process of Biology studying in a basic secondary school has been substantiated.

1 INTRODUCTION

Specificity of the modern information society leads to a change of the ways of human life. This causes significant transformations in the educational system. Its transition to a qualitatively new state requires the optimization and management of the mechanisms of interaction of all the subjects of learning environment.

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Its peculiarity is the functioning of multi-vector information flows that need to be taken into account in the educational process. There is a replacement of the subject-subjective educational paradigm by a polysubjective one (Spivakovska, 2016). Within such a system of relations, all the subjects of the educational process interact with each other as active mutually influential participants. They interact with modern information technologies (IT), social networks, Internet services, and others. That is why a new educational communicative paradigm is actualized, which means communication in a polysubjective learning environment.

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New challenges, which face the society related to the COVID-19 pandemic, have forced biology teachers to reconsider the technical capabilities of information technologies in distance learning (Bobyliev and Vihrova, 2021). One of the advantages of using the LearningApps.org online resource is the possibility to integrate tasks into distance learning systems and self-directed learning: pupils can remotely perform a variety of tasks of biological content. The teacher does not need to spend time checking assignments, because the assessment automatically goes to his personal account.

Modern IT involve wide opportunities of various social networks to the development of pupils. In consequence of the potential of mass interactivity, immersion, learning in joint activities, they become an effective tool of learning. The appropriateness of IT use in the process of Biology school course studying is caused by the specifics of the object of biological cognition (life in all its manifestations) and the concept of bio(eco)centrism, which recognizes the life of any organism as the highest value (Komarova and Starova, 2020).

Biology studying at secondary schools in Ukraine is aimed at the formation of ten major key competencies (Shokaliuk et al., 2020), among which are the following: information and digital competence and key competencies in natural sciences and technologies. It is relevantly to form such competencies using modern information devices in the educational process. We consider a computer, an interactive whiteboard Smart Board, a multimedia projector, a tablet, a smartphone, Google Chromecast adapter, and others to be the modern information devices.

A works (Doroshenko et al., 2005; Lavrentieva et al., 2020; Matiash, 2004; Mironets and Torianyk, 2018; Savosko et al., 2021; Nevedomska, 2007; Shcherbakov, 2006; Stepanyuk, 2011) have dealt with the possibilities of using a computer in the process of Biology teaching. Matiash (Matiash, 2004) underlines the necessity of using a computer during Biology school course to increase the effectiveness of the lesson and the efficiency of the learning process. Stepanyuk (Stepanyuk, 2011) studies the problem of using computer learning tools in the methodological training of future biology teachers. Nevedomska (Nevedomska, 2007) considers the positive and negative aspects of the use of computer technologies in Biology teaching while examining the levels of information and computer systems that form the quality criteria of the theoretical and practical implementation of pedagogical computer tools.

Theoretical aspects of mobile learning are disclosed in (Horbatiuk and Tulashvili, 2013; Kosyk, 2014; Malchenko et al., 2021; Mironets and Torianyk, 2018; Skrypka, 2015). Methodology of website using in the process of Biology teaching in a basic secondary school is revealed by Stepanyuk and Mironets (Stepanyuk and Mironets, 2019). The essence and possibilities of using the LearningApps.org online resource are described by Aman (Aman, 2019). Fedosenko (Fedosenko, 2020), Bonch-Bruievych et al. (Bonch-Bruievych et al., 2007) studied the use of the LearningApps.org builder as one of the means of SMART technologies in the process of Biology teaching.

However, the analysis of scientific and pedagogical works shows that the practical aspect of using the LearningApps.org online resource for conducting educational studies in biology with the help of information devices was not the subject of a separate study and is not enough described. Therefore, there is a contradiction between the innovative nature of the development of information devices, online resources and the development of scientific and methodological support for their implementation in the educational process in biology.

The *objective* of this paper is to outline the possibilities, as well as the appropriateness of using the LearningApps.org online resource in the process of Biology school course studying with the application of information devices.

The objective was realized through the following tasks:

1. To clarify the state of development of the problem at the levels of pedagogical activity and personal property of pupils.
2. To develop and substantiate the methodology of using the LearningApps.org online resource in the process of Biology school course studying with the application of information devices and to test experimentally its effectiveness in a basic secondary school.

2 RESEARCH METHODS

To achieve the abovementioned objective and tasks, a number of methods have been used, namely: theoretical – comparative analysis to find out different views on the problem, identify areas of study; modeling to develop a methodology for using the LearningApps.org online resource in the process of Biology school course studying with the application of information devices; systematization and generalization to formulate conclusions and recommendations for improving the educational process in biology; empirical – generalization of pedagogical experience, scientific observation, interviews, content analysis, questionnaires in order to determine the state of implementation of the problem in practice and to develop the content of experimental teaching methodology; pedagogical experiment, which provided verification of the effectiveness of the proposed methodology.

Experimental research has been carried out on the basis of Ternopil general secondary schools No. 24, 26, 28, Terebovlia general secondary school No. 1 (Ternopil region) and Sumy general secondary schools. Summative experiment involved 528 pupils, 212 biology teachers and 68 future biology teachers, who are now students of the second (master's) level of higher education of Ternopil Volodymyr Hnatiuk National Pedagogical University and Sumy State Pedagogical University named afer A. S. Makarenko. Forming experiment lasted for two years (2018–2019 and 2019–2020 academic years) in 6th grades in the process of Biology school course studying. 1006 pupils participated in it.

Effectiveness of the proposed methodology was checked during the forming experiment.

The goal of the forming experiment was to test the effectiveness of the developed methodology of using the LearningApps.org online resource in combination with information devices. We drew a conclusion about the quality of the experimental methodology according to the criterion "coefficient of completeness of knowledge acquisition" (A. A. Kyverialg's method). It was determined using formula 1 (Kyverialg, 1980):

$$K = \frac{\sum I_0}{n \cdot I_a} \cdot 100\%, \quad (1)$$

where K – the coefficient of completeness of knowledge acquisition;

n – the number of pupils who performed the work;

$\sum I_0$ – the sum of elements of knowledge acquired by each pupil;

I_a – the number of alements of knowledge communicated to each pupil.

According to the criteria of completeness of knowledge acquisition, developed by Bespalko (Bespalko, 1968), the educational material was considered to be acquired, and knowledge formed if the coefficient of knowledge acquisition was higher than 70%. It is believed that a pupil with such a coefficient of knowledge acquisition is able to further improve his knowledge through self-education.

The forming experiment was carried out in the conditions of real educational process on Biology studying in the 6th grade. It involved the creation of experimental (EG) and control groups (CG) of pupils. In EG pupils absorbed botanical knowledge (anatomical, physiological, systematic, agronomic and ecological notions) in the process of studying themes according to our experimental methodology of using the LearningApps.org online resource in combination with information devices. Experimental training was carried out during the study of Theme 3 "Plants" (approximately 20 hours) and Theme 4 "Plant diversity" (approximately 12 hours) (MON, 2017). Pupils in CG studied according to the traditional, dominant in modern secondary school, methodology of forming biological notions.

Thematic controls of the results of pupils' from control and experimental groups acquisition of elements of botanical knowledge (notions) – morphological, anatomical, physiological, systematic, agronomic and ecological were carried out in three stages: Stage I – after studying the themes "Root, steam: structure and basic functions. Variety and modifications of vegetative organs. Photosynthesis as a characteristic feature of plants, nutrition, respiration, plant movements"; Stage II – after studying the themes "Plant reproduction: sexual and asexual. Vegetative reproduction of plants. Flower. Inflorescence. Pollination. Fertilization"; Stage III – after studying the themes "Algae. Mosses. Gymnosperms".

The choice of these themes is determined by the carried out content analysis of their content and the results of the summative experiment. It proved that the acquisition of anatomical, physiological and systematic notions causes significant learning difficulties for schoolchildren.

After conducting each stage of thematic control, the mistakes made by pupils, their causes, ways to adjust and improve the methodology were analyzed.

3 RESULTS AND DISCUSSION

With the aim to study the state of the problem in the practice of Biology teaching we carried out a survey of 212 biology teachers and 528 pupils of the city schools in Sumy and Ternopil regions. We analyzed the way teachers train pupils to work with different sources of information. Thus, 43.87% (93 teachers) train pupils how to work with the catalogue, 73.58% (156 teachers) train how to work with the textbook orientation apparatus, 24.53% (52 teachers) form the ability to search the necessary information on the Internet.

198 teachers (93.40%) use computer as a tool for Biology teaching, an interactive whiteboard Smart Board is used by 46 teachers (21.70%), 86 teachers (40.57%) use multimedia projector, a tablet and

a smartphone is used by 10 teachers (4.72%), and 8 teachers (3.77%) use Google Chromecast Adapter. All the 212 teachers (100%) use computer during the preparation to the lessons. However, only 154 teachers (72.64%) give their pupils home task to search for the additional information on the Internet, and 198 teachers (93.39%) offer pupils to prepare presentations in the form of a report on the performance of a specific task. There are the following reasons for the inadequate use of modern information devices by teachers in the educational process: insufficient level of their own computer literacy – 104 teachers (49.06%); lacking of material and technical as well as educational and methodological support for Biology school course teaching– 148 teachers (69.81%); the reluctance of teachers to study phenomena and processes of wildlife using a computer – 52 teachers (24.53%). Only 10 teachers (4.72%) know that a mobile device can be used as a tool for teaching Biology. Only 23 respondents (10.85%) use the LearningApps.org resource in the process of Biology school course studying. At the same time only 13.04% out of them are aware of the feasibility of integrating this resource with mobile devices at the lesson.

With the aim to find out main advantages and disadvantages of using the LearningApps.org software in school practice, a survey of 64 future biology teachers, who are now students of the second (master's) level of higher education was carried out. The students were introduced to the LearningApps.org resource during practical classes in advance and completed a teaching practice, in the process of which they modelled and conducted lessons using this online resource. The results of the questionnaires showed that future biology teachers identified the following positive aspects of working with LearningApps.org: many opportunities to create a variety of didactic tasks (90.63%); expanding opportunities for the use of visual and illustrative applications (67.19%); doing exercises it is possible not only to check, but also to correct mistakes (56.25%); exercises are effectively used to train pupils' attention and memory (39.06%); it is not necessary to print the material on paper, it is enough to send it to the pupils' personal account on the phone (100%); a large number of convenient templates that are available and easy to use (90.63%); the ability to view pupils' learning outcomes statistics and control their knowledge (78.13%); the exercise can be accessed using a special QR-code, which facilitates pupils' access to the exercise and saves time at the lesson (75.00%); the online resource is completely free (100%); possibility to create tasks in Ukrainian (100%); possible acquaintance with exercises from different countries, which were previously developed by other teachers and use them in the own work (56.25%); availability of video, audio and graphic materials (89.06%); the use of the online resource is easy and saves a lot of time at the lesson and when the teacher checks tasks (46.88%); convenient use of the program during remote work (100%); it is always possible to change, improve, expand and differentiate already created tasks by the teacher (78.13%); the online resource is easy to use for pupils' independent work and learning additional material (90.63%).

Among the disadvantages of using the LearningApps.org resource future biology teachers named: the main condition for using the program is the Internet connection (not all pupils may have sufficient access to the Internet and not all schools still have full access to the Internet) (100%); when updating the interface of the LearningApps.org site, some tasks may not work if there were changes in the structure of the task template (56.25%); in some templates, in the instructions to them the translation into Ukrainian is not completely available (18.75%); not all the exercises that are available for use are true and may contain mistakes (39.06%); the teacher can use only ready-made exercise templates, but cannot create templates himself (18.75%); logging in to the program is possible only through an Internet browser, there is no specially created application that will facilitate logging in (45.31%).

All the respondents had a positive attitude towards the opportunity to use the LearningApps.org resource in the process of practical activities and its combination with mobile devices.

The majority of pupils have shown moderate interest to the TV programs about nature (77.65%). Only 7.20% claimed that they are not interested in such programs at all. 60.23% of pupils like observing plants and animals and 16.10% demonstrate moderate interest in such an activity. 74.43% of pupils sometimes address the Internet sources to answer questions during the lesson and 19.70% of the pupils often address various information sources in this case. 5.87% of the pupils stated that they don't search for the answers in additional sources.

The majority of teenagers (87.31%) possess mobile devices (smartphones, tablets), but they use them mainly for fun or socializing with peers in social networks. 18.56% of pupils know that a mobile device can help in conducting a research both at school and beyond it, but only 4.55% of respondents use smartphones for this purpose.

However, the study of the practice of modern secondary schools and personal teaching experience show that the use of the Internet facilitates better learning of education material by pupils. The LearningApps.org online resource is designed for developing and storing didactic multimedia interactive tasks, through which the teacher can form, consolidate and test the acquired knowledge, skills and abilities of each pupil in educational, play-based form, which contributes to the formation of cognitive interest, motivation to learn, critical thinking and independence. At the same time the effectiveness of lessons increases significantly and it encourages pupils to study. The educational process is intensified through the increase of its informativeness. Due to this, pupils improve their ability to orient themselves in the information space and, in this case, the teacher acts as a mentor, consultant. All the above mentioned actualizes the necessity in the development of the methodology of Biology studying using the LearningApps.org online resource in combination with information devices.

Our experimental methodology involves the use of the LearningApps.org online resource in combination with the following information devices: a computer, an interactive whiteboard Smart Board, a multimedia projector, a tablet, a smartphone, and Google Chromecast adapter. The main attention is paid to the use of the m-learning technology. It is caused by the main advantages of its use, namely: bringing new technology into the classroom; possibility to use portable devices to support the learning process; possibility to use the technology as an additional tool for learning; as a useful add-on tool for pupils with special needs; available synchronous learning experience; allows widened opportunities for timing, location, accessibility and context of learning (Striuk et al., 2015).

The challenges of introducing m-learning technology were also taken into account. Among them are as follows: accessibility and cost barriers for users; incompatibility of some mobile devices with other applications and devices; frequent changes in device models, technologies, functionality; number of file (asset) formats supported by a specific device; risk of distraction and fragmentation of learning; restriction of educational information visualization; required bandwidth for nonstop and fast streaming; tracking of results and proper use of the information and the lack of well-developed pupils' self-control skills; insufficient "technical" training of school teachers in creating of mobile application (Tsesarska, 2002).

Smartphones and tablets based on the Android operating system allow you to use online resources and various free applications that are downloaded from the PlayMarket server. Analyzing the PlayMarket server, it has been found that it contains a lot of applications that are permanent helpers in the biology learning with the possibility of free downloading. All applications are installed on the teacher's smartphone, and using Google Chromecast adapter, they are displayed on the multimedia projector screen.

There are some examples of using templates of the LearningApps.org online resource for teachers to create their own exercises at the Biology lesson:

Exercise "*Find a pair*" is a universal task that can be used by the teacher at any stage of the lesson and in the process of studying various themes. Pupils like images, text information, or videos to help them match the right pairs. A bright example is to match the image of the plant to its name (which taxonomic link it belongs to). If a pupil forms a pair correctly, the colour is green, but if a mistake is made, the pair is shown in red.

Example: you can see images of the main representatives of the Gymnosperms group and their species names on the Smart Board (figure 1). Pupils come up to the board in turn and try to match an image and a species name. There is an exercise check at the end (highlighting correct and incorrect answers in colours).

Exercise "*Classification*" is used for selective sorting of statements, notions, videos, audios, or images according to a corresponding common theme. Preparing for a Biology lesson a teacher can use it for the systematization of knowledge, matching, or consolidating of the corresponding educational material.

Example: you can see statements on the board, which can be referred to two groups: Gymnosperms and Ferns. Pupils classify the statements, explaining which of the groups it can be referred to. There is answers check at the end (correct answer is highlighted in green and incorrect answer is shown in red colour).

Figure 2 presents an illustration of the exercise "Classification", which should be used when studying the types of inflorescences with the help of the LearningApps.org online resource at different stages of the lesson: perception of information, clarification and expansion of knowledge, reproduction of information, generalization and systematization of knowledge.

Another bright example of this exercise is classification of statements. Pupils are offered to sort all the statements according to their belonging to a certain class: Monocotyledons and Dicotyledons. If the pupil's answer is correct it is highlighted in green and incorrect matching is shown in red colour.

Exercise "*Simple ordering*" the main goal of which is to arrange the proposed statements, images in a certain order (establishing a sequence). There is a

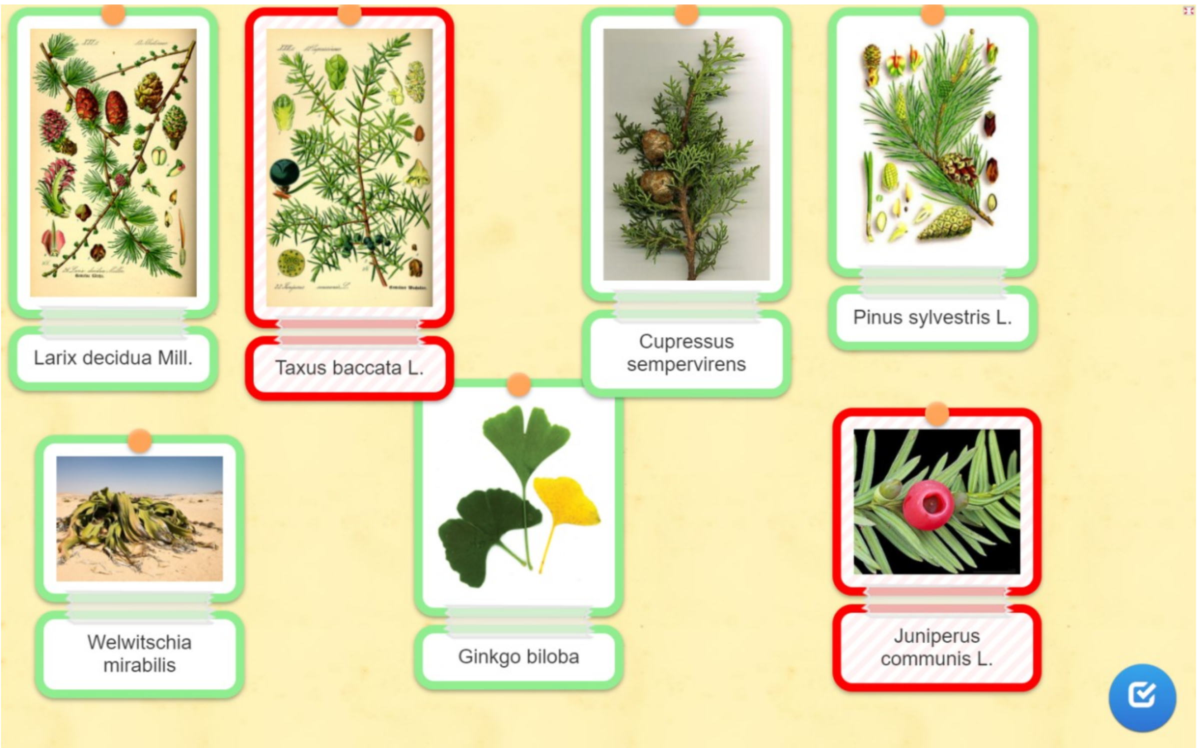

Figure 1: Illustration of the exercise "Find a pair". Learning of plant species "Gymnosperms group" in the LearningApps.org online resource (https://learningapps.org/display?v=pk1msmk7321).

numbering in the upper left corner, which is changed, when you move the statements. It can be used during Biology lessons for the sequential arrangement of development cycles, body structure, physiological processes, and others.

Example: during the lesson on the theme "Subclass Equisetidae" pupils get acquainted with different stages of the equisetum development cycle. It is necessary determine the correct sequence. The stage which was correctly determined is highlighted in green, false stage is shown in red (figure 3).

Exercise "*Quiz (1 correct answer)*" can be practically used when the teacher develops test tasks. Using clear instruction, the teacher can create questions with different numbers of answer options. Questions can be in text, audio or video format. The teacher decides on the number of questions himself. Pupils' answers are sent to the teacher's personal account, which makes it easier to check the tasks and does not take much time.

Exercise "*Fill in the blanks*" is used for filling in certain parts of the text. Pupils are offered certain part of the text with blanks in it. It is necessary to fill in the blanks: choosing from the list of proposed options, or choose the statement independently from the learned material. Each of the pupils can do this exercise using his mobile phone. Advantages of use: each of the pupils can test his knowledge himself, online discussion of this exercise is possible and the results of the answers are automatically sent to the teacher's account, pupils can also see and analyze the correctness of the completed tasks themselves. The exercise can be used at the stage of motivation, homework checking, consolidation of knowledge, or reflection.

Another example of this exercise is the work with a textbook (Matiash, 2004). Pupils should study a part of the theme on the basis of the textbook, namely on the example of the main features of flowering plants (Angiospermae). The text without answer options is provided on the board, or on the mobile phone (if the teacher sends the task to pupils in advance), pupils in turn at the board (or on the mobile phone independently) fill in the answers, according to the learned material. The correct answer is highlighted in green; the incorrect answer is shown in red colour. The answers are sent to the teacher's account, then there is a mutual reflection with the class and correction of mistakes with pupils' explanations and if it necessary the teacher may add something.

Exercise "*Crossword (puzzle)*" has a user-friendly interface for building a layout and creating tasks. Using the template, the teacher only needs to create

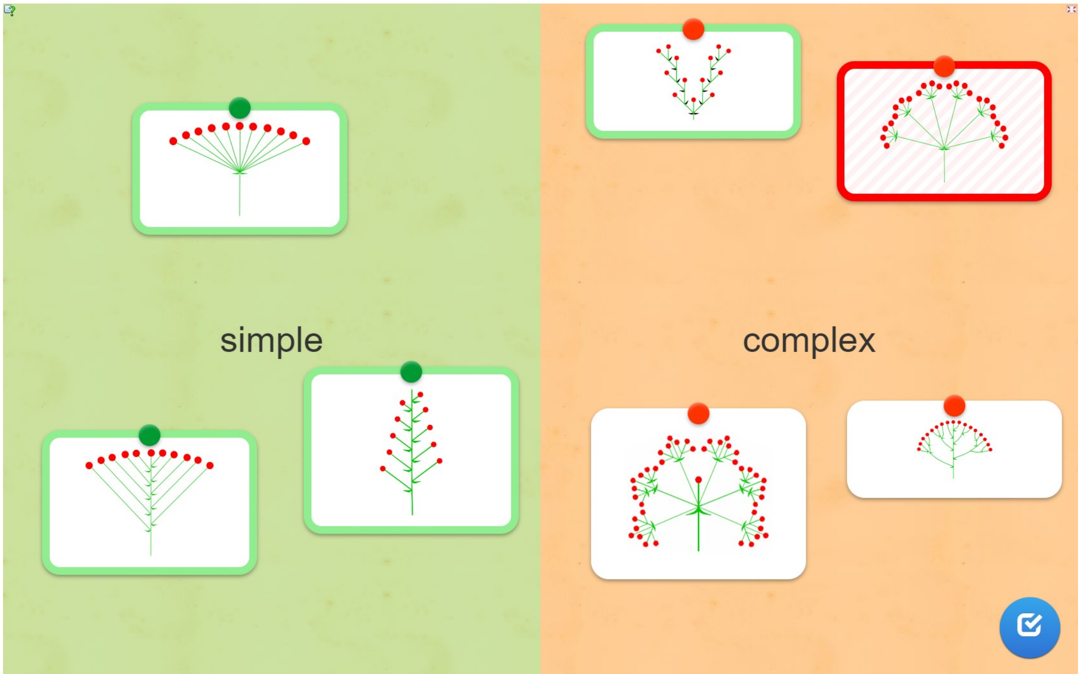

Figure 2: Illustration of the exercise “Classification”.

questions and choose the correct answers to them. The program itself builds a crossword puzzle by placing words vertically and horizontally and determines the appropriate intersections of words. The teacher can also choose a keyword that is relevant to the theme of the lesson. The exercise can be used at the stage of motivation, revision of the learned material, consolidation of knowledge. The development of this exercise is quite easy and clear and can be used for independent pupils’ work, in the case of sufficient knowledge how to use the LearningApps.org online resource. Example:

1. In the life cycle of the considered groups prevails... ? (Sporophyte)
2. What do extinct plant species form? (Coal).
3. Where does photosynthesis take place in horsetail (Equisetum)? (Stem).
4. What is the limiting factor in fertilization of the considered groups (Water).
5. What is the underground part of Lycopodium? (Root).
6. How are horsetails (Equisetidae) dispersed? (In groups).
7. Where are spores of the considered groups formed? (Strobilus).
8. Give a clear name for the sexual generation of horsetails (Equisetidae) and lycophytes? (Gametophyte).
9. What is the photosynthetic organ of Lycopodium? (Leaf).
10. What do young steams of horsetail (Equisetum) contain in great amounts? (Starch).
11. What part of lycophytes is used to make baby powder? (Spores).
12. What is the indicator for soils with high acidity? (horsetail (Equisetum)).

Pupils can see the illustration of crossword puzzle on the Smart Board, and they immediately answer the questions on it, checking the correctness of the answers at the end.

Exercise “*Find the words*” is used as an educational game. Pupils are offered a list of questions to answer and find them on the word search board one next to the other. The program creates the word search board itself where the words are arranged horizontally, vertically and diagonally. This exercise is used at all stages of Biology lessons, especially it is offered for knowledge actualization. Example:

Questions:

1. Embryonic leaves that are found and developed in the seed? (Cotyledon).
2. Modified steam of flowering plants (Angiospermae) group? (Flower).
3. What fertilization (give the name) leads to the formation of a seed and fruit? (Double).

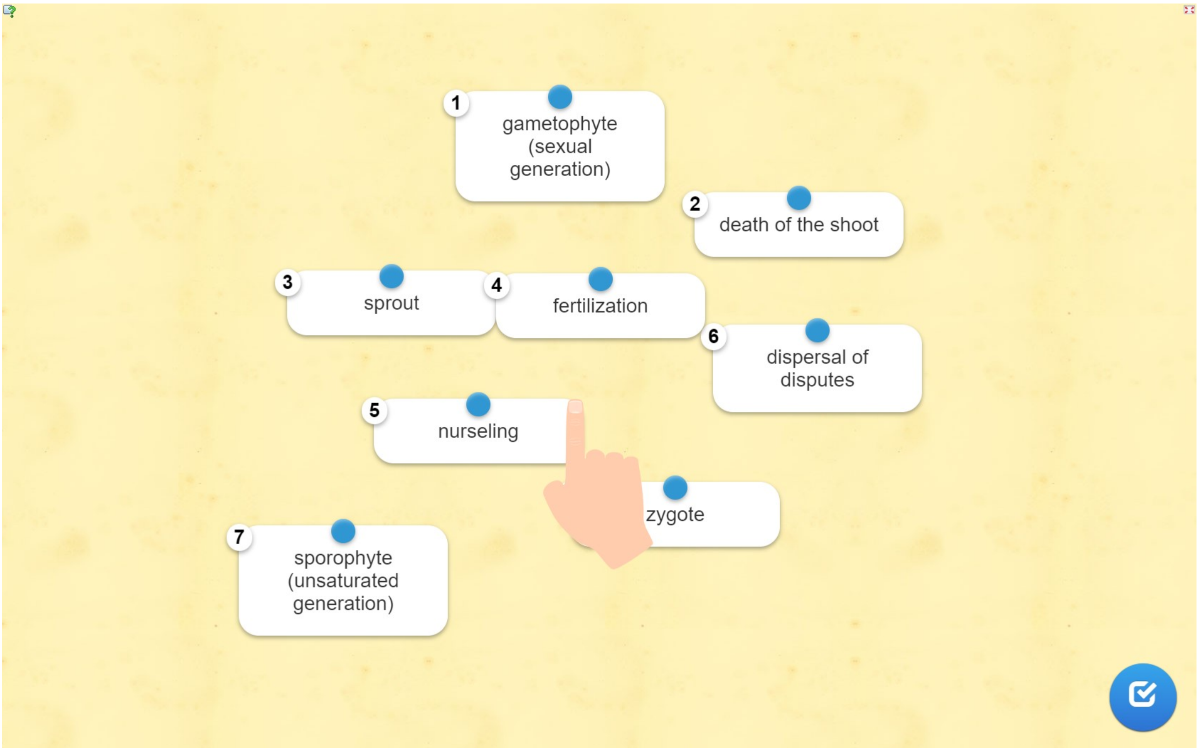

Figure 3: Illustration of the exercise “Simple ordering” – arrange stages of the life cycle of field horsetail (Equisetum arvense) in the right order using the LearningApps.org online resource.

4. Which class do the Lily and Cereal families belong to (give the name of the class)? (Monocotyledons).
5. What type of root system do Dicotyledons have? (Taproot).
6. The diversity of which organs of flowering plants (Angiospermae) group improves and increases the species composition of vital functions performing? (Vegetative).
7. What class do Rosaceae and Asteraceae families belong to? (Dicotyledons).
8. Name the type of Dicotyledons venation? (Reticulate).
9. The root system of Monocotyledons is. . . ? (Fibrous).
10. Where is the seed protected by a pericarp that has an adaptation to the dissemination? (Fruit).

Pupils are given a table with encrypted words and questions to them. They answer the questions and find the appropriate answer in the table. The correct answer is highlighted in colour.

We present examples of educational applications, involved in our methodology.

In our previous research (Stepanyuk et al., 2019) the effectiveness of using such free applications of the PlayMarket server as “Anatomy 4D”, “Animal 4D+”, “Augmented Reality Dinosaurs – my ARgalaxy”, “BioInc – Biomedical Plague, BioInc” , “Plan+Net” in the process of Biology studying in a basic secondary school was proved. Their choice is caused by the specifics of the object of biological cognition (life in all its manifestations) and the concept of bio(eco)centrism, which recognizes the life of any organism as the highest value. Comparison of the content of these applications with the content of the program material in Biology for the 6th grade allowed us to conclude that it will be the most appropriate to use the “Plan+Net” application for our experimental methodology, which is a powerful tool to identify plants in the photo. During an excursion the teacher takes a picture of an unknown plant by his smartphone and then using the mobile application analyzes the received information. After the work completing, plant details can be checked using printed version of a plant catalogue. Pupils can use such an educational application not only at Biology lessons, but also during their individual work in the process of research at the centers of research and experimental activities.

The use of information devices at a lesson at the stage of homework checking allows to diversify the forms of pupils’ learning outcomes control. Thus, in addition to computer testing, Miracast wireless technology can be used for this purpose. This requires the owning of a smartphone, a multimedia projector and Google Chromecast adapter. There is a great deal of educational content available on Google Play Market application of your smartphone, including programs for pupils' learning outcomes control. One of them is Plickers. This web server lets you survey your class at the lesson and conduct instant checks for understanding of the learned and current material in a test form.

To start working with it, it is necessary to download a free application Plickers to the teacher's smartphone. Then, in a separate application, prepare the tests and print a set of cards. One set of cards can be used for different classes. Each pupil is assigned a unique Plickers card that has a black and white image similar to a QR code. The number of the card corresponds to each pupil (according to the list). Then you will need to take your smart device, choose the Plickers application.

Choose the class and necessary question from the list. The chosen on your mobile device question will be automatically displayed on the screen with the help of a projector. Using the scanner of your smartphone scan your pupils' cards and record their answers. Pupils should hold their cards so that the letter of the correct answer is located at the top. Colored highlighting helps to find out how well the pupils answer the questions quickly: grey marks the pupils who haven't answered yet, red means incorrect answers of pupils, and green stands for correct answers.

The use of Smart technologies makes it possible to solve the following topical issues: use the latest IT in training; improve the skills of pupils' independent work in information databases, the Internet; improve the pupils' knowledge, skills and abilities; make the learning process more interesting and meaningful; develop creative potential; control through testing and a system of questions for self-control; increase the cognitive activity of pupils due to various video and audio information (Doroshenko et al., 2005).

Smart Board is a touch screen, which is connected to a computer. Multimedia projector transmits an image from the computer screen to the Smart Board. The latter acts as an interactive touch screen monitor for the computer. By touching the Smart Board, the user is able to click on buttons, highlight text and drop and drag items right from the Smart Board.

An interactive whiteboard helps the teacher to work with a variety of multimedia visual aids that allows you to display an object in a variety of ways. In the course of his work a biology teacher can use everything that the pupil is able to perceive clearly.

While working with the Smart Board, there is a rapid increase in the amount of visual information, which in its turn increases the quality and effectiveness of the lessons. Unique possibilities of Smart involve pupils in active cognitive activity and enhance their creative potential. There is a chance to work with a large amount of information at the lesson that creates the optimal conditions for pupils' individual research work in biology. Pupils work with computer models, during such work they can carry out experiments and check hypotheses.

During the work with the Smart Board a number of traditional didactic principles are being implemented: sequence, systematic character, scientific approach, visual training, pupils' activity and consciousness, connection of theory with practice, availability and duration of knowledge. The principles of visualization, availability and systematicity are realized through adding tables, video and audio materials, and analysis of materials of electronic textbooks during the explanation of new material. However, the interactive whiteboard is mostly used during the principle of visualization due to which you can present educational material in the form of schemes, dynamic algorithms or generalizing tables, which are a concise statement and an illustration of the main conceptions of the material and its use at the lesson.

Our methodology involves the use of a website as a means of increasing the effectiveness of the learning process. Nowadays any teacher can create a website. There are hundreds of different website building platforms and website builders. You can get either free or for the payment information-technological base and real resource in the form of electronic space, modules, templates, control systems.

Site pages can be simple static file sets or created by a special computer program on the server. It can be either custom-made for a specific site, or be a ready-made product designed for a specific class of sites. The structure of a website consists of two parts: internal and external. The internal part of the structure is represented by the headlines, sub sections, site sections, labels and other navigation elements. The external part of the structure of a website is a scheme of the content blocks, that is, how the header, the main content, the comment block, and other elements of the site are located. A well designed website layout, where convenient and interesting interface is combined with actual information is a very important point in the development of this resource and it is better perceived by users (Skrypka, 2015).

Having analyzed the functions and tasks of various websites, we chose the website builder Ucoz. The appropriateness of this website builder choice is caused by the fact that it contains all the necessary components for creating namely a training website and allows to create multy-functional universal websites free of charge. It involves a sufficiently large number of educational category templates, with an appropriate interface, convenient ways to add and edit existing web pages, site management options from both the control panel and the admin panel that rejects force majeure during learning, because if you have problems with logging into the admin panel, the teacher will be able to manage the site through the control panel. This builder contains a specific, comprehensible control panel which requires registration and has a definite password used to log in. It will protect the site against hacking, illegal spreading of information which is stored on it, as the website administrator has certain copyrights.

In the context of experimental learning we have developed a methodology for organizing a biology teaching process in a basic secondary school using the LearningApps.org resource and various information devices. We used them variously at lessons of different types: at the introductory lesson, to activate the cognitive process and to report new knowledge; at the lesson of studying new material; at the combined lesson in order to expand and deepen the pupils' knowledge; at the lesson of checking and correction of knowledge for final control and correction of knowledge.

The LearningApps.org resource was used together with other information devices at different stages of the lessons: at the stage of actualization basic knowledge: tests (Plickers application), video clips (Smart Board), models of objects and phenomena (Smart Board); at the stage of learning activity motivation: coloured drawings, animated snippets, virtual biological experiments, website; at the stage of learning new material: photos, slideshows, animated plots, interactive models (website), video clips (Smart Board); at the stage of summing up of the studied material: multiple-choice tests (Plickers application), mute pictures (Smart Board), establishment of sequence of biological processes (Smart Board); at the stage of generalization and systematization of obtained knowledge: thematic control with automatic verification (Plickers application), control – diagnostic tests (website).

They were also used in various forms of learning: during the class work and practical classes (website); during virtual excursions (Smart Board); during pupils' individual work and research (website); while doing pupils' homework (website, mobile applications).

Conducted research allows to make a conclusion that using a training website in biology teaching process greatly facilitates pupil-teacher interaction. It is advisable to use a training website to prepare pupils for independent work on the tasks that the teacher places in advance in the suitable section on the website. At the lesson preceding the lesson of generalization and systematization of knowledge, the home assignment will be as follows: the pupils should refer to the website, the address of which is reported by the teacher, and in the section "Preparing for independent work" do the assigned tasks (there may be different variants). At the lesson of generalization and systematization of knowledge it is necessary to do the tasks placed on the site, or to use them as a plan for the survey of pupils. Thus, they can revise, generalize, systematize the obtained knowledge and fill in the gaps. By using the website in preparation for the pupils' independent work, we give them more time to prepare and diversify the process, which will then have a positive impact on the learning outcomes.

Using a website is also productive at the lesson that precedes practical work. Biology teaching involves performing such practical work that requires certain conditions that cannot be created in the classroom. For the fairness of the experiment and obtaining accurate results, it is better to ask pupils to carry out this practical work at home with the help of their parents, and to place the plan of work and instructions how to carry it out in the section "Practical work" on the website before conducting it and, to discuss the results at the stage of actualization knowledge at the next lesson.

It is convenient to place some research themes on this training website, as this will help to prepare for pupils' conferences, because they will be able to get the theme at the beginning of the academic year and work at it throughout the year and after that to defend it at conferences. The website can store all the theoretical information necessary for conducting lessons so that the pupil can access it at any time. This way of placement is convenient for pupils who were absent from the lesson, as they can independently study the material which was missed in the home environment.

Generalized results of the thematic assessment on the themes, during which the experimental methodology of using the LearningApps.org online resource in combination with information devices in the 6th grade was implemented are presented in table 1.

Analyzing the data of table 1, we can see that pupils acquired knowledge in all the themes which were taught using experimental methodology. This is evidenced by the average value indicator of the coefficients of teaching information acquisition (76.42%).

The results of the Stage I of pupils' thematic assessment on the themes "Root, steam: structure and

Table 1: Results of acquisition the elements of knowledge by pupils of the experimental group.

No.	**Program themes**	**Elements of knowledge (notions)**	I_a	n	$n \cdot I_a$	$\sum I_0$	K, %
1	Root, steam: structure and basic functions. Variety and modifications of vegetative organs. Photosynthesis as a characteristic feature of plants.	morphological	6	491	2946	2254	76.51
		anatomical	3	491	1473	1089	73.93
		physiological	6	491	2946	2185	74.16
		agronomic	1	491	491	405	82.48
2	Plant reproduction: sexual and asexual. Vegetative plant reproduction. Flower. Inflorescence. Pollination. Fertilization	morphological	11	503	5533	4188	75.69
		anatomical	1	503	503	386	76.73
		physiological	3	503	1509	1104	73.16
		agronomic	1	503	503	437	86.87
3	Algae. Mosses. Gymnosperms	morphological	2	482	1928	1467	76.08
		anatomical	2	482	964	773	80.18
		physiological	5	482	2410	1695	70.33
		systematic	3	482	1446	1115	77.10
		agronomic	2	482	964	710	73.65

basic functions. Variety and modifications of vegetative organs", Photosynthesis as a characteristic feature of plants, nutrition, respiration, plant movements" are shown in figure 4.

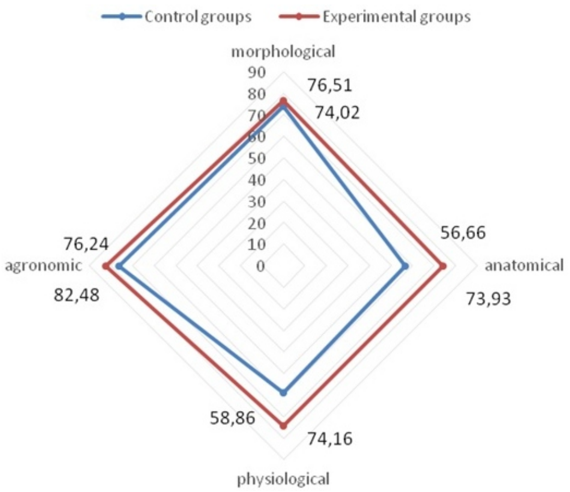

Figure 4: Coefficients of pupils' acquisition of the elements of botanical knowledge (Stage I of the thematic assessment).

According to the state requirements for the level of pupils' general educational background, laid down in the current program in Biology, the study of the themes "Root, steam: structure and basic functions. Variety and modifications of vegetative organs", Photosynthesis as a characteristic feature of plants, nutrition, respiration, plant movements" involves pupils' learning of morphological, anatomical, physiological and agronomic notions. Analysis of the results of doing the tasks with morphological content showed that pupils have learned this educational material (K = 74.36% – in CG and K = 76.51% – in EG).

As it can be seen in figure 4, the coefficient of pupils' acquisition of the anatomical and physiological notions has considerably increased in EG (from 56.66% and 58.86% to 73.93% and 74.16%, respectively). We believe that the effectiveness of knowledge acquisition is connected with the proposed methodology of teaching pupils using the LearningApps.org online resource. The formation of such notions as "photosynthesis", "respiration", "evaporation", "transportation of substances in the plant" is possible only with a rational combination of traditional visual aids (tables, diagrams, experiments) and the use of multimedia fragments, that what the experimental methodology included.

A comparison of the answers to the questions with agronomic content showed that the results of thematic assessments of pupils' academic achievements from CG and EG did not differ significantly (76.21 and 82.48, respectively).

A comparison of the thematic assessment results on the themes "Plant reproduction: sexual and asexual. Vegetative plant reproduction. Flower. Inflorescence. Pollination. Fertilization" is shown in figure 5.

The results of pupils' educational information acquisition proved that the most significant impact the proposed methodology of using the online resource LearningApps.org in combination with information devices has on the formation of anatomical (K = 76.73%) and physiological notions (73.16%). At the same time the difference in coefficients of knowledge acquisition in CG and EG is + 11.38% and + 16.31%, respectively. It can be explained by the fact that for the pupils of this age group (12-13 years old) the physiological processes of "pollination", "fertilization" and "plant development" are difficult to understand and remember. It is difficult to show these processes and to form the holistic visual representa-

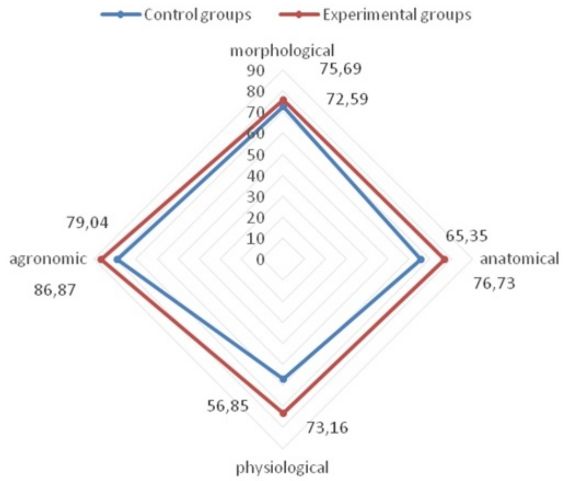

Figure 5: Coefficients of pupils' acquisition of the elements of botanical knowledge (Stage II of the thematic assessment).

tion of the mechanisms of their occurrence with the help of traditional static means of visualization.

The results of the Stage III of pupils' thematic assessment on the themes "Algae". "Mosses". "Gymnosperms" according to the coefficients of knowledge elements acquisition (morphological, anatomical, physiological, systematic, and ecological) in control and experimental groups are shown in figure 6.

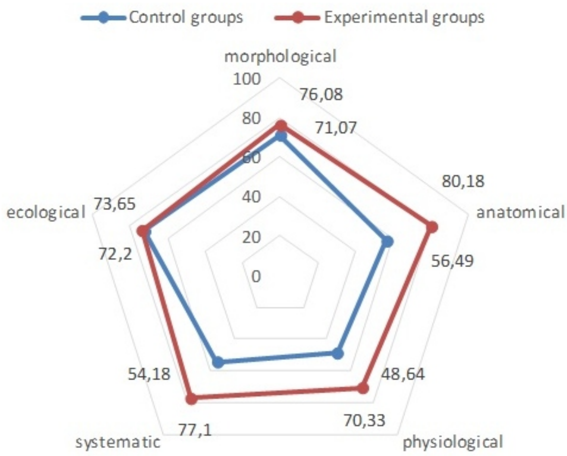

Figure 6: Coefficients of acquisition of the elements of botanical knowledge (Stage III of the thematic assessment).

The analysis of the results of tasks on the themes "Algae", "Mosses", "Gymnosperms", which involved the acquisition of morphological knowledge (figure 6) showed that this knowledge is acquired by pupils at a sufficient level ($K = 71.07$) using traditional teaching. Undoubtedly, using of the LearningApps.org online resource for training, in particular, the demonstration of images of the organs of higher sporophytes and gymnosperms promotes better memorization of educational information, as evidenced by the coefficient of knowledge acquisition ($K = 76.08$).

The most significant impact of using the online resource LearningApps.org in the process of studying we observe at those stages where anatomical (K = 56.49% in CG and K = 80.18% in EG) and physiological (K = 48.64% and 70.33% respectively in CG and EG) notions are formed. It is difficult to form these notions using traditional mediums of instruction (tables, microscope, textbook). The use of pedagogical software with dynamic multimedia fragments helps to illustrate the complex processes of reproduction of higher sporophytes and algae, their better visual perception.

In the process of pupils' systematic notions acquisition, it is important that they possess already formed morphological, anatomical and physiological notions. Since after using the LearningApps.org online resource in EG, the coefficient of these notions acquisition increased, this can explain the increase of the coefficient of systematic notions acquisition (K = 54.18% in control groups and K = 77.10% in experimental groups).

Analysis of the answers to the questions with ecological content allows to confirm that this material can be considered to be learned as the coefficient of educational information acquisition both in CG and EG is higher than 70%.

Thus, the comprehensive analysis of the results of the forming experiment allowed us to conclude that proposed by us methodology of using information devices in the process of Biology school course studying is effective.

4 CONCLUSIONS AND PERSPECTIVES OF FURTHER RESEARCH

Modern IT allow to create a single information environment, the basis of which is integrated computer networks and communication systems, which gives an opportunity to accompany and coordinate educational processes. When introducing online resources and information devices into the educational process in Biology, the principle of reasonable conservatism and continuity must be observed. The computer cannot substitute a teacher in the process of teaching; it is only a means of broadening possibilities to acquire new knowledge. The teacher always has to play the key role in any educational innovation. This justifies the appropriateness of moving to a mixed form of training that involves the creation of a polysubjective educational environment (teacher, pupil, online resource, information devices).

The LearningApps.org resource has a lot of advantages: availability of the service in different languages (including Ukrainian), access to unregistered users, the ability to use tasks created by other users, a wide range of task types, tips for completing and developing tasks, easy to use, accumulation of own exercises in a personal profile, creating pages to work with different classes.

There are a great number of benefits of using this digital app, but there are also some negative qualities: some templates do not support Cyrillic script, the school must be connected to the Internet, there are some errors in the templates that cannot be corrected manually, some exercise templates change or they are removed from the site.

The use of the LearningApps.org service helps in versatile and purposeful formation of pupils' educational competencies and allows to achieve the goals more effectively by involving each pupil in cognitive, creative, active activities, combination of logical and figurative thinking.

The methodology of using the LearningApps.org service in combination with information devices in the process of Biology studying in a basic secondary school involves the use of the PlayMarket server applications, Smart technologies and a website. It is relevantly to use free applications of the PlayMarket server while studying Biology in a basic secondary school. They are as follows: "Anatomy 4D", "Animal 4D+", "Augmented Reality Dinosaurs – my ARgalaxy", "BioInc – Biomedical Plague, BioInc", "Plan+Net". Their choice is caused by the specifics of the object of biological cognition (life in all its manifestations) and the concept of bio(eco)centrism, which recognizes the life of any organism as the highest value. During homework checking it is advisable to use Miracast wireless technology besides computer control of pupils' learning outcomes. This demands the owning of a smartphone, a multimedia projector, and a Google Chromecast type adapter. It would be appropriate to use the website builder Ucoz for creation of a training website in Biology.

Based on the synthesis of the obtained data, recommendations for the use of a Biology training website were developed: the use of the website should not be the only means of training; each lab work using a training website must be preceded by a mandatory introductory instruction; the information in the sections should be precisely matched to the relevant theme of the lesson; the answers to the questions for self-examination should be mandatory checked, either in the course of group activity at the lesson or individually, in order to trace the gaps in the knowledge of a particular pupil; take into account wishes of the pupils, because in order to enhance their academic performance, socialization and improvement, such a training website is created.

The educational process which involves the use of the LearningApps.org service and information devices encourages the independent work of each pupil, creates a favorable communication situation and conditions for the development of creative abilities of the individual, which are especially important for each pupil; increases the motivation and cognitive activity of pupils, improves the individualization, differentiation and intensification of the learning process, broadens and deepens interdisciplinarary links, systematizes and integrates knowledge of certain subjects, organizes systematic and reliable control, avoids subjectivism in assessment. In addition the use of the methodology of the LearningApps.org service and information devices integration in the process of Biology studying significantly simplifies the interaction between pupil and teacher, allows to combine the formation of logical and figurative pupils' thinking.

The prospects for further study consist in the studying of the influence of the methodology of the LearningApps.org service in combination with information devices on the formation of pupils' general and subject-based competencies in the process of Biology studying; preparing of future biology teachers to model educational activities using the LearningApps.org service in combination with information devices.

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The Current State of using the Cloud-based Systems of Open Science by Teachers of General Secondary Education

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Keywords: Cloud-Oriented Methodological System, Teacher Training, Science and Mathematics Subjects, Scientific Lyceums.

Abstract: The article presents the analysis of the results of the ascertaining stage of the pedagogical experiment "Design of a cloud-oriented methodological system of training teachers of natural and mathematical subjects to work in a scientific lyceum". An analysis of recent research and publications has shown that scholars have sufficiently considered the problem of reforming teachers' training. A valuable trend is revealed in Ukrainian research on the design of cloud-based systems, it is devoted to the systems of open science, but the proposed systems relate exclusively to certain specialties, or are entirely scientific. Currently, there is no cloud-based system that would become a tool in the teachers of science and mathematics training to prepare them to work in the scientific lyceum. The current state of the art of using open science services by teachers of natural and mathematical subjects during the preparation of educational materials was clarified; the readiness of teachers to perform their own research and teach students to conduct research work is analyzed and the level of teachers' awareness of the functions and requirements of scientific lyceums is determined. The analysis of the conducted survey showed that most teachers recognize the need in scientific activities for a teacher of a scientific lyceum. Most respondents do not use English language resources and services due to their low level of language proficiency. It has been found that one of the most important ways to get involved in science, as for the math teachers' view, is the participation in scientific conferences. Analysis of the results of the ascertaining stage of the pedagogical experiment shows that there is a problem of preparing teachers of natural sciences and mathematics for work in the scientific lyceum. It needs further solution through preliminary testing and implementation of a specially created cloud-based methodological system that would support the introduction of the open science systems and services in teachers' training and educational process.

1 INTRODUCTION

Nowadays, teachers of science and mathematics are faced to quite high demands concerning the mastery of the subject and the professionalism of teaching the younger generation. The modern teacher should study throughout life, be interested in innovations in the field of information technology in order to diversify and improve the presentation of educational material. This is an objective necessity nowadays. However, in 2020, due to the epidemiological situation in Ukraine, in order to implement the Resolution of the Cabinet of Ministers of Ukraine No. 211 of March 11, 2020 "On preventing the spread of coronavirus decease COVID-19" in Ukraine, a letter was approved by the Ministry of Education and Science of Ukraine, No. 1/9-173 of March 23, 2020. The letter states that: "Under quarantine conditions, teachers work with students at home by using distance learning technologies, taking into account the material and technical opportunities of the educational institution". That is, a modern teacher of natural sciences and mathematics must be ready to organize distance learning for students and have all the necessary techniques for its effective implementation. It should be noted that the Regulation on distance learning was adopted on April 30, 2013 by the Ministry of Education and Science of Ukraine (MON, 2013). There is the only ways to implement distance learning: the use of distance learning technologies. Therefore, there is a need to fill possible gaps in teacher education, in particular, through the introduction of cloud technology in the training process.

The advantages of using cloud services in ed-

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ucation have been repeatedly discussed in (Bondarenko et al., 2019; Lytvynova, 2016; Shyshkina, 2015; Vakaliuk, 2019). Among them: saving computing resources of the device; simultaneous work of online user groups; study and work anywhere and anytime; performing tasks from any device (the need is only to connect to the Internet); organization of distance learning online.

The use of the cloud-based systems of open science in the process of teachers' training is now poorly studied and elaborated and needs further investigation.

2 LITERATURE REVIEW

The system of forms of teacher training in accordance with the requirements of the New Ukrainian School were described in (Marchenko, 2019). It was identified that the basis of modern teachers' training courses is the development of creativity, creativity, professional abilities and skills. The cloud technologies are briefly reviewed as a means to be familiar with certain topics of the subject area and perform individual practical tasks.

Krutova (Krutova, 2019) studied the problem of using information and communication technologies in the system of professional development of teachers. Krutova (Krutova, 2019), in particular, provides a list of Ukrainian and foreign platforms (distance learning courses) for teacher training.

Yevtushenko (Yevtushenko, 2018) identified the goals and objectives of advanced training of teachers of natural sciences and mathematics in terms of reforming education in Ukraine. In another study Yevtushenko (Yevtushenko, 2019) examines the problem of teachers' information culture, which he considers as the ability to perceive and learn something new.

Shyshkina (Shyshkina, 2015) studied the problem of designing a cloud-based educational and scientific environment of higher education. The main problem outlined in (Shyshkina, 2015) are: the considering of methodological principles of creation and development of educational and scientific environment of higher education institution based on cloud technologies, determination of criteria for its formation and evaluation.

The research (Lytvynova, 2016) is devoted to the cloud-based learning environments as a tool for solving problems related to the learning mobility of all participants in the learning process. Vakaliuk (Vakaliuk, 2019) defines the meaning of the concept of "cloud-based learning environment for bachelors of computer science" and provides a description of the structural model of cloud-based learning environment for bachelors of computer science.

Kuzminska (Kuzminska, 2020) researched theoretical and methodical bases of designing and application of digital educational environment of scientific communication of masters-researchers.

Mayer (Mayer, 2015) studied the problems of open science, e.g, the terminological apparatus and areas of use of open science.

Marilyn and Edrick (Marilyn and Edrick, 2012) considered using the Science-Forums.net platform for scientific collaboration.

Researchers have considered the problem of teachers' training in accordance with the basic provisions of the New Ukrainian School Conception and put forward the idea that the program of teachers' training courses should include the study of cloud technologies. However, this is not a comprehensive study for the further use of the system of cloud services that will help teachers in preparing for work in the scientific lyceum. There are also some studies on the use of ICT in the educational process, the features of ICT and their shortcomings. However, the problem is very widely disclosed, it is not specified and is not focused on a specific target group. Also, some studies have considered the issue of updating advanced training courses for teachers of natural sciences and mathematics in connection with the reform of education in Ukraine.

Scientists have sufficiently considered various models of organization of the educational process using information and communication technologies (ICT). In addition, scientists have developed models of cloud-based environment, in particular for the training of relevant profiles. However, the problem of designing a cloud-oriented methodological system for preparing teachers of science and mathematics to work in a scientific lyceum remains insufficiently studied.

The current state of preparation of teachers of natural sciences and mathematics for work in the scientific lyceum requires additional research and analysis. In particular, the skills of the use of the relevant ICT tools or cloud services at each stage of research should be considered. These prerequisites caused the need to launch a scientific and pedagogical experiment "Designing a cloud-oriented methodological system for training teachers of science and mathematics to work in a scientific lyceum" in 2019.

The main task of the research is to analyze and interpret the results of the ascertaining stage of the pedagogical experiment "Design of the cloud-oriented methodical system of training teachers of natural and mathematical subjects to work in a scientific lyceum", revealing the readiness of the Ukrainian teachers for using the cloud-based systems of open science in the educational process.

3 METHOD

In a previous study (Shyshkina and Marienko, 2020) outlines the term “adaptive cloud-based system of open science”: “it is a cloud-based system (based on a cloud platform), which in its parameters can be automatically adjusted by the goals and objectives of the scientific cooperation process, different individual features and educational and scientific needs of the participants of the virtual research team” (Shyshkina and Marienko, 2020). Since this study is not about adaptability, we can say that the technology of cloud-based systems of open science means purposeful, specially organized sets of information processes using cloud-based systems that meet all the principles of open science.

The pedagogical experiment on “Designing a cloud-oriented methodological system for training teachers of natural sciences and mathematics to work in a scientific lyceum” was launched in 2019 as part of the planned research “Adaptive cloud-based system of training and professional development of teachers of general secondary education” (DR No. 0118U003161, 20182020), conducted at the Institute of Information Technologies and Learning Tools of the National Academy of Educational Sciences of Ukraine. Research work is carried out on the basis of 6 institutions of higher education of Kherson State University, Kryvyi Rih State Pedagogical University, Ternopil Volodymyr Hnatiuk National Pedagogical University, Rivne Regional Institute of Postgraduate Pedagogical Education, Bogdan Khmelnitsky Melitopol State Pedagogical University and Zhytomyr Polytechnic State University. Experimental work on the design and use of a cloud-based system of traing and professional development of teachers of scientific lyceums is planned as a natural, cross-pedagogical experiment, which consists of the following stages: preparatory and research. Thus, the research stage is divided into: ascertaining, forming and control.

The *purpose* of the experiment is to design and verify experimentally the cloud-based methodological system of training teachers of natural sciences and mathematics to work in a scientific lyceum.

The use of cloud technologies and cloud services in the educational process is a promising trend of modern Ukrainian and foreign research. The methodological principles of the cloud-based learning and research environment design are well investigated by the Ukrainian scientiests in the recent years (Vakaliuk, 2019; Lytvynova, 2016; Shyshkina, 2015). At the same time, the cloud services are purposfully used both the educational process of institutions of higher education and general secondary education institutions. Cloud-oriented learning environments have some advantages for educational institutions in the organization of the educational process and the use of learning technologies.

The cloud-based system can provide services such as remote access to learning tools for higher education institutions to save on local and public funding in a cost-effective way. Students can access classes on a laptop, tablet, or phone from anywhere and use them freely. At the same time, the student can ask and answer questions and share what has been learned to help others. Access to analysis and user data means that such a system can be adapted to ensure maximum efficiency for both users and the education system. But most importantly, it helps young people access to access to learning anywhere, anytime, from any experienced teacher.

It turns out that most teachers of pedagogical schools are familiar with cloud services and express their intention to use cloud-based systems in the educational process. It was found that teachers who use a particular cloud service in the learning process fully involve all its possible tools. However, due to the lack of methodological developments, the use of cloud-oriented systems calls into question the effectiveness of their pedagogical use.

The purpose of the *ascertaining stage* of the pedagogical experiment is: to find out the current state of use of services by teachers of natural and mathematical subjects during the preparation of educational materials; to find out the readiness of teachers to perform personally and teach students to conduct research; to determine the state of awareness of teachers about the functions and requirements in scientific lyceums.

At the ascertaining stage, the experimental work was conducted in cooperation with Rivne Regional Institute of Postgraduate Pedagogical Education (2019) and Zhytomyr Polytechnic State University (2020). The following methods were used: questionnaires, interviews and observations. At the stage when the experimental sites were identified, two questionnaires were developed for each institution separately. The primary quantitative analysis of the experimental data is provided and the obtained results are summarized by means of distribution diagrams, tables and their interpretation is fulfilled. The quantitative analysis is to describe the current state of this problem. The reliability of the results is confirmed by the involvement of teachers from all regions of Ukraine.

4 RESULTS

4.1 Rivne Regional Institute of Postgraduate Pedagogical Education

The questionnaire, developed for students of two groups of mathematics teachers of Rivne Regional Institute of Postgraduate Pedagogical Education, consisted of 13 closed questions (2 dichotomous and 11 alternative multivariate) and one open, short. At the beginning of the questionnaire, the respondent indicates in which city he / she works (teachers were from different cities of Rivne region, in order to determine the territorial distribution) and his / her educational institution. The next point is to indicate which subjects the respondent reads, because at school a mathematics teacher can additionally teach other subjects. Thus, out of 45 respondents, not only mathematics teachers, but also 2 methodologists and 4 teachers were among the respondents. The aim was to find out the knowledge of mathematics teachers about the basic provisions and conditions of work in the scientific lyceum, how much teachers are interested in conducting research (one of the main requirements of work in the scientific lyceum) and involving students in research.

One of the key questions was to determine whether respondents understand how important is it for a science high school teacher to ne engaged into research, as this is a basic requirement. It was found that the majority of teachers (43 respondents out of 45 respondents, which is 96%) believe that a teacher of a science lyceum should be engaged in scientific activities. At the same time, teachers who took part in the survey, in particular, submit articles to professional publications in Ukraine only for certification – 34 respondents (76%).

Only 10 teachers (22%) submit an article to a professional publication at least once a year. This is evidence that teachers are reluctant to publish their own research or do not have enough time to do so. Another possible reason is that teachers underestimate the necessary to be engaged in scientific research. These reasons were established during the interviews and clarification of certain issues related to the survey.

In the content of the cloud-oriented methodological system of training teachers of natural and mathematical subjects to work in the scientific lyceum there is a need to use English-language resources and services (specialized and general purpose). Therefore, the goal was to determine whether teachers were able to use English-language resources (not necessarily cloud-based). However, the results were not comforting enough: 35 respondents (78%) do not use any English-language resources or services. This is the evidence that in order to test and further implement a cloud-based methodological system of training teachers of science and mathematics to work in the scientific lyceum should develop detailed organizational instructions using certain tools and services (including English).

If the teacher uses only printed resources in English, some research may be needed to determine the level of skills in using cloud services. During the interview, it was found that teachers want to work with English-language services, however, they first need to master the skills of working with an online translator or installing plug-ins and applications to speed up the work and make it more comfortable. Such preparatory moments will not distract from the learning process and save time and effort (the teacher does not need to translate each menu or button with a printed dictionary, because, unfortunately, there are such situations). In order to find out the skills and abilities of conducting research work, the respondents answered the following questions: research of the state of the scientific problem, participation in scientific activity and implementation of the obtained research results.

A rather interesting result was that respondents are familiar with open science services (21 people, which is 47%). 22 respondents (49%) answered that they rely on their own experience to formulate and study the state of a scientific problem, but this is not enough, because in this case the scientific problem will not be fully investigated. Questionnaire answer options were designed to cover every aspect of the problem and to consider as many possible life options as possible.

The most common ways for teachers to participate in scientific activities were: participation in conferences (24 respondents, 53%) and individual scientific activities (21 respondents, 47%). Perhaps this will be enough for the secondary school (at least participation in conferences), however, if a teacher plans to work in a scientific lyceum, then cooperation with higher education institutions and project activities will play a significant role. Individual scientific activity, without combination with other ways of participation in scientific activity, will generally give a rather weak result, because in this case there are no discussions, exchange of experience and constructive criticism (discussion of existing methods, establishing new connections).

Among the ways of implementation and use of the obtained research results the most common are:

publication of methodical materials (selected by 22 respondents, 49%) and self-implementation (selected by 19 respondents, 42%).

At the same time, self-implementation is not a very effective way, because one teacher will not be able to cover a geographically large enough number of participants. Therefore, this implementation will be local and available only to a narrow circle of participants (especially if the teacher does not sufficiently publish the results of their work, showing previous survey results).

4.2 Zhytomyr Polytechnic State University

The questionnaire "Skills of working with cloud services", developed for four groups of students of the distance course of educators on the basis of Zhytomyr Polytechnic State University, consisted of 13 closed questions (3 dichotomous and 10 alternative multivariate) and one open, short. Some questions of the questionnaire are duplicated with those that were in the questionnaire for mathematics teachers of Rivne Regional Institute of Postgraduate Pedagogical Education. As in the previous survey, the respondent indicates in which city he works (educators from all regions of Ukraine took part in the survey) and his educational institution. Mandatory field to fill in – it is necessary to indicate which subjects the respondent reads (it was necessary to cover not only mathematics teachers, as the target group is teachers of natural sciences and mathematics). Thus, among the 824 respondents surveyed were teachers of computer science, mathematics, Ukrainian language and literature, English, history, biology, physics, foreign literature, geography, chemistry.

If you analyze the questions that are present in both questionnaires, you can trace certain patterns. The majority of respondents (789 people) believe that a teacher of a scientific lyceum should be engaged in scientific activity (95.8%). If we evaluate the use of English-language resources (services) by teachers, we can say that 66.9% (551 respondents) do not use, 31.8% (262 respondents) use such resources and 1.3% (11 people) use only printed English resources.

One of the main issues during the ascertaining stage of the pedagogical experiment is to determine the most common services among teachers that they use in preparation for the lesson. This issue is extremely important, because for the further implementation of a cloud-based methodological system, you need to have at least basic knowledge for the use of cloud services and their principles of operation. As can be seen from the results of the survey, only 548 respondents use cloud services in preparation for the lesson (66.5%). 574 (69.7%) – still used a local ICT tools. That is, teachers can not even assess the benefits of cloud services and their use in organizing group work of students.

The next stage of research was to assess the skills and abilities of teachers to use individual resources and services at different stages of research. After all, if the teacher has sufficient skills to work with services, he will later be able to teach this and his students by offering them as an alternative, such as spreadsheets. What resources are used by teachers to search for scientific (educational and methodological) literature are shown in Fig. 1. Among the answer options, the most common services were chosen, those that are available to teachers. Also, the list included open science services, as they can act as separate components of the cloud-oriented methodological system of training teachers of natural sciences and mathematics to work in the scientific lyceum.

As can be seen from the chart, 98.9% of respondents (815 respondents) use Google search. Almost half of the respondents (424 people, which is 51.5%) use printed materials to find the right material. At the same time, repositories (16.5%), journal systems (14%) and Google Scholar (14.9%) remain almost unnoticed. It is clear that a rather small number of teachers use open science services (4.4%), as a quarter (only 26.8%) of respondents are familiar with the concept of open science. This is 221 respondents (26.8%) out of 824.

Even fewer respondents know about the European Open Science Cloud – 191 (out of 824 respondents), which is 23.2%. These questions were necessary to clarify the state of awareness of teachers with the latest scientific trends. After all, the use of individual components of the European Open Science Cloud can be quite useful for preparing teachers to work in a scientific lyceum. In addition, the European Open Science Cloud contains about 220 cloud services that teachers can successfully use in the learning process (the main advantage is free and open access). But this is possible only with the appropriate techniques.

Teachers of scientific lyceums must not only bring the scientific component into the educational process, but also be able to organize each stage of research work of students using modern ICT tools. Apparently, one of the leading services can be considered cloud services, because they are focused on the use of anywhere and anytime (on any device) and do not restrict students to use only sufficiently powerful devices (do not depend on the technical characteristics of a device). Therefore, the use of teachers of a service to organize the joint work of students was studied

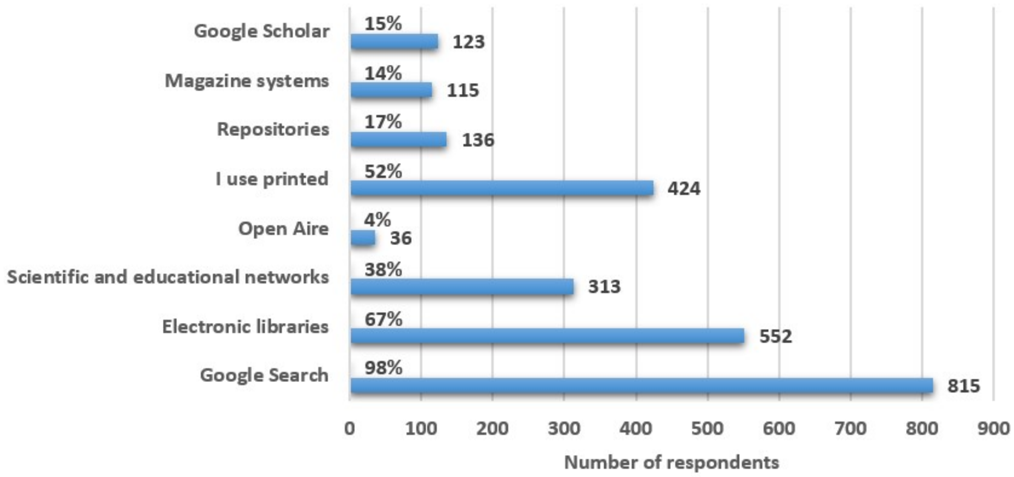

Figure 1: Teachers use services to search for literature.

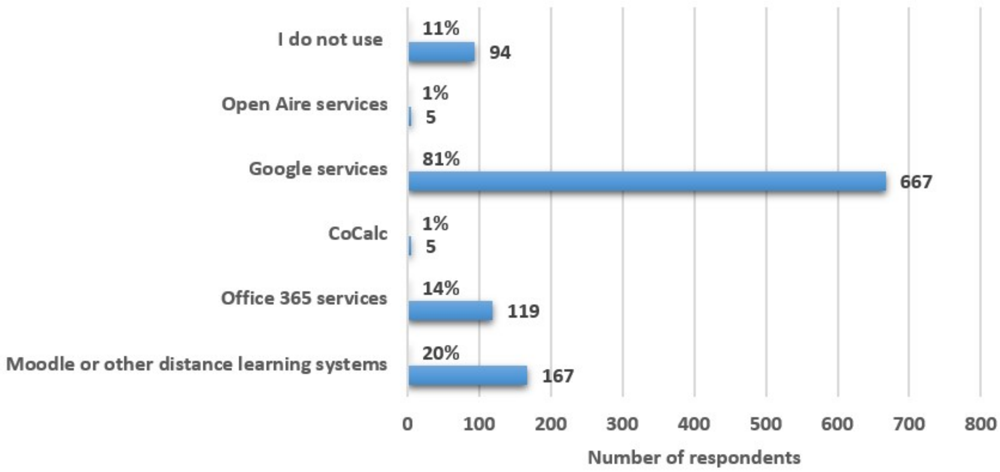

Figure 2: The use of services by teachers to organize the joint work of students.

(figure 2). As can be seen from the chart, Google services are the most popular among teachers, they were chosen by 667 respondents (80.9%). Only 20.3% of respondents (167 people) use a system of distance learning courses such as Moodle to organize joint work of students in the classroom. It is unfortunate that 94 respondents (out of 824 respondents, 11.4%) do not use any services to organize group work of students.

The analysis of the answers (figure 2) shows a low level of use by teachers of distance learning systems, specialized cloud services and some tools of the European Open Science Cloud (0.6%). This indicates that there are some problems in preparing teachers of science and mathematics to work in the scientific lyceum, because this situation makes it impossible to fully organize the educational process using modern cloud services, ICT tools at a high, scientific level.

5 CONCLUSIONS

Analysis of the results of the ascertaining stage of the pedagogical experiment “Designing a cloud-oriented methodological system of training teachers of science and mathematics to work in a scientific lyceum” showed that there is a problem of training teachers of science and mathematics to work in a science lyceum. Although most of the participants in the statement phase of the pedagogical experiment are aware of the need of a teacher of a scientific lyceum in scientific activity, but teachers are not ready to work in a scientific lyceum. In particular, most respondents submit articles to professional publications in Ukraine only for certification and do not always use rational ways to pose and study the state of a scientific problem. Observations and individual interviews have found that teachers generally do not consider it necessary to engage in science, let alone encourage students to do so.

According to teachers, one of the main ways to participate in scientific activities is to participate in conferences and individual scientific activities. Publication of methodical materials and self-implementation, according to teachers, are one of the most promising ways to implement and use the results of the study. Teachers' use of lesson preparation services is mostly limited to online services and ICT tools on the local computer (cloud services are also used, but to a lesser extent). Most respondents use scientific and methodological literature to search: Google search, electronic libraries and printed sources. Only a quarter of respondents are familiar with the concept of open science and the European Open Science Cloud. And most teachers use Google services to help students work together. Thus, it turns out that most respondents use only localized resources and services, which significantly narrows the range of possible cloud services in the learning process, in particular, to organize collaboration, data processing, search for literature and information and more. In addition, among the possible variety of cloud services of open science, the most famous of them are practically not used. As a prospect for further research is the experimental implementation of a model of cloud-based methodological system of training teachers of natural sciences and mathematics to work in the scientific lyceum in the educational process of Kherson State University, Zhytomyr Polytechnic State University and Kryvyi Rih State Pedagogical University. The final stage of research and experimental work is the statistical processing and analysis of the results of the formative stage of the pedagogical experiment.

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Analysis and Prospects of the Future Teachers Training of the Integrated Course “Natural Sciences”

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Keywords: STEM education, STEM learning, Educational programs, Interdisciplinary, Pre-service teachers

Abstract: The analysis of four curricula of teachers training of natural sciences in higher education institutions is presented in the paper. The question of curricula developing for pre-service teachers of natural sciences and introducing integrated courses in biology, physics and chemistry studying and conducting a new specialization in the educational branch “Secondary Education” should be studied. We analyzed the characteristics and the current state of curricula implementation into the educational process. The analysis of the normative framework regulated the teacher’s activity is also made. In the framework of the components of teacher’s professional activity there is considered terms of qualification characteristics. The considered professional standards and qualification characteristics made it possible to conclude the curricula correspond to the normative documents and modern requirements for the professional teacher’s activity. The analysis of four curricula by sections is carried out. It made possible to compare the list of their components and the logical sequence of courses and to determine their common and distinctive features. The existence of the integrative component of each curriculum and its conformity to the formation of the professional competences of future teachers was established. The use of problem-oriented learning technology can form the subject competence, formulated in accordance with the basic subjects: physics, chemistry, biology, natural science. Subject competence in science is an integrative part of the course. They are based on the formation of the integrity of representations of nature, the use of science and information on the basis of operation of the basic general laws of nature. The classification of integrated courses is made on the basis of the nature of the relationships between disciplines and the integration degree. The existence of integrative components in the list of the educational-professional/scientific program and their conformity with the classification of the integration of courses is established. We also defined the disciplines of influence on the formation of integrative competences of pre-service teachers of integrated courses of natural sciences.

1 INTRODUCTION

Since 2010, specialized training has been introduced in the senior grades of general educational institutions, according to which students of humanitarian classes study more than 20 individual subjects, including low-hour natural subjects (physics – 2 hours per week, chemistry – 1 hour, biology – 1.5 hours, and geography 1.5 hours). It led to the memorization of a large amount of information that the students did not need in the future.

In accordance with the order of the Ministry of Education and Science of Ukraine, from the 2016/2017 academic year, a new specialty “Secondary education (natural sciences)” has been added to the list of specialties “Secondary education”. It is allowed to train applicants for higher education in providing for the second specialty (subject specialty) “... including those that provide the teaching of integrated courses defined by the institution of higher education” (MON, 2016a). The educational program states its peculiarity is “... integrative training for the performance of functional duties of subject teachers: biology teacher, chemistry teacher, physics teacher and teacher of the integrated academic subject “Natural Sciences”, class teachers in secondary educational institutions, organizers circles of natural direction in institutions of additional education; formation of readiness for self-education and professional self-improvement throughout life”. Students got a bach-

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elor's or master's degree and they have possibility to get the professional qualification/subject specialty of a teacher of natural sciences, physics, chemistry, biology.

Since 2018, an experimental program of teaching students in 10th – 11th grades in the integrated course "Natural Sciences" has begun in one hundred educational institutions of Ukraine (MON, 2019; Nechypurenko et al., 2021). The explanatory note of the course says that "the course is designed only for students who do not study in natural and mathematical profiles, and for whom natural subjects are not decisive for choosing a future profession". The authors define the main goal of the integrated course "... the formation of the natural science worldview of students, providing them with general education in the natural sciences, mastering the methods of scientific knowledge to explain physical, chemical, geophysical, biological, ecological and other natural phenomena; solutions to applied problems that are encountered in the students' life of and their families, in society and in the life of humanity as a whole. These are mainly situations related to health and disease, the natural resources use, the state of the environment, the impact of science and technology".

At present, the four experimental programs for studying the course "Natural Sciences" at school have been developed. These programs integrate topics from the natural sciences, biology, ecology, astronomy, physics, chemistry, and geography into integrated classes and projects. The analysis of the programs and corresponding textbooks showed that the authors suggest the scientific worldview formation in schoolchildren, ideas about the world's natural-scientific picture, the development of scientific thinking.

Such changes in legislation and education require the training of new qualified personnel who are able to conduct educational activities in accordance with the approved study programs of the integrated course "Natural Sciences" and have a high level of STEM culture, to ensure the modernization of these programs throughout the teacher's professional activity in the context of constant development technologies and the impact on society.

One of the sources of integrated learning can be considered the introduction of interdisciplinary connections, which began to be investigated back in the 1960-1970s as a means of educational knowledge enhancing, the assimilation of scientific concepts, patterns by students (Anan'ev, 1966; Esipov, 1964; Sukhomlinskiy, 1959). Study of the general foundations of didactics in the 1970-1980s, which were engaged in (Danilov, 1974; Lerner, 1964; Skatkin and Kraevsky, 1978) intensified the problems of the school education content improving, the development of cognitive activity and the independence of schoolchildren. The innovation was the concentrism reduction, the integrated subjects and courses introduction, the allocation of intra-subject and inter-subject connections. The integration of the main types of children cognitive activity is widely used in our time in various options for organizing integrated classes at different levels of education from preschool to higher education. The researches (Arnold, 2010; Bannan-Ritland, 2003; Booth, 2011; Booth et al., 2009; Bretz Jr. and Thompsett, 1992; Cambridge, 2008; Dean et al., 2020; Durrant and Hartman, 2015; Eysenck, 1963; Ferrett et al., 2013; Froyd et al., 2007; Galvin, 2006; Gross and Pinkwart, 2015; Gupta and Boyd, 2011; Hinchliffe and Wong, 2010; Kutt et al., 2019; Lowenstein, 2015; Mang et al., 2017; McLoughlin and Thoms, 2015; Park, 2019; Shetty et al., 2001; Walshe et al., 2013; Woodside, 2018) are discussed the issues.

Analyzing scientific and methodological publications, we can conclude the main research areas are related to the development of the individual courses and the integration of the content of various academic subjects. The following issues are also considered: compliance with state standards, an activity approach and project-based training in integrated courses, course content development, competence-based approach. However, the question of the educational programs formation for the future teachers training, teaching the integrated course "Natural Sciences" is not fully covered.

The *aim* of the study is to analyze the educational programs of the specialty "Secondary education (natural sciences)" for preparing teachers for conducting integrated courses at universities.

2 RESULTS

The gradual introduction of STEM education, according to (IMZO, 2021), requires the creation of practice-oriented teaching methods, curricula within the disciplines of training courses. Such methods and programs at the bachelor's and master's level are already being introduced in some higher education institutions (Valko et al., 2020; Morze et al., 2018; Semerikov et al., 2021). In 2019, nine higher educational institutions are training future teachers of integrated disciplines according to curricula "Secondary education (natural sciences)". Such curricula are developed by teams of authors specializing in various scientific fields. For example, at developing of a specialty program “Secondary education (natural sciences)” at the Ternopil Volodymyr Hnatiuk National Pedagogical University (TNPU), a team from the departments of general biology and methods of teaching natural disciplines, chemistry and teaching methods, physics and methods of teaching it, geography and teaching methods worked. At Mukachevo State University (MSU), representatives of the departments of mechanical engineering, natural sciences and information technology, theory and methods of primary education, tourism and recreation took part in the creation of the program. A team of specialists from the departments of technological and vocational education and general technical disciplines, social work, social pedagogy and culture, general pedagogy, preschool, primary and special education worked on the creation of the program at the Izmail State Humanitarian University (ISHU). At the Poltava V. G. Korolenko National Pedagogical University (PNPU), the program was created by the departments of botany, ecology and teaching methods of biology, chemistry and teaching methods of chemistry, geography and teaching methods, general physicist and mathematics.

In accordance with the requirements of the “Guidelines for the description of the educational program in the context of new standards of higher education” (MON, 2016b), educational programs have a certain structure. It makes possible to compare them and identify common and distinctive features.

Each of the programs provides the formation of integrative competencies, which provide an understanding of the knowledge of the future teacher and his capabilities after successful completion of training. Comparison of these competencies with the requirements for a teacher, according to the above regulatory documents, showed that they fully comply with the established educational standards (Kramarenko and Nochvinova, 2019). The educational program and curricula determine the nature of the relationship between disciplines and the integration degree. There are the following types of integrative courses (Meeth, 1978):

1. *Integration based on one discipline* – focusing on each discipline provides students with specialized skills and concepts in the field. Specialized training provides teachers and students with an in-depth knowledge of the field. At the same time, such a study can lead to information fragmentation and does not reflect the completeness of scientific research. There is a lack of knowledge about the relationship between different subjects. This type is possible for theoretical courses, as a basis for further study of scientific concepts and the formation of an understanding of the directions of scientific research in certain industries.
2. *Study of parallel courses / modules* – in this case, the content of each subject does not change. Thus, the effect is achieved when students can independently or with the help of a teacher to establish connections between individual phenomena. The only drawback is that students do not see the collaboration between teachers. In addition, such work requires sufficient planning time.
3. *Additional courses or disciplines* – the comparison of several disciplines focused on one problem, without a direct attempt at integration.
4. *Integrated courses / modules* – are short-term project activities. Selected activities built on the interaction between different subjects. Efforts are aimed at solving socially important issues.
5. *Integrated days* – long-term projects, primarily on topics and problems arising from their own experience.
6. *Complete program* – fully integrated programs in which the daily learning of students is linked to their lives. An example is the summer science camp.

The curricula provides theoretical and practical training aimed at mastering the basics of fundamental knowledge in basic (compulsory) disciplines and optional disciplines, during which general and professional competencies are formed. The analysis of the curricula made it possible to classify some of the disciplines as those that provide subject competencies in the following areas (Valko, 2019):

- *scientific* (S) – disciplines form the scientific picture of the world, provide the ability to identify, analyze scientific models, apply theories. Basic disciplines such as chemistry, biology, basic scientific research, and the like were included in this category;
- *technological* (T) – disciplines form the ability to use modern technologies in professional activities and have an idea of their development trends. This category includes disciplines such as programming, information technology, etc.;
- *engineering* (E) – disciplines form competencies in the design and modeling of objects using modern technologies. This category included such disciplines as the demonstration experiment, the basics of electronics;
- *mathematical* (M) – basic disciplines introduce mathematical models and methods for describing objects and processes. Disciplines in this area, for

example, mathematical analysis, higher algebra, probability theory.

The ratio of the number of credits between the directions is shown in figure 1. As you can see, the ratio between the different directions is different, which indicates a difference in educational approaches and scientific profiles of universities.

Since the disciplines of technological, engineering and mathematical blocks for specialization are not basic, then in educational programs the basis is formed by the disciplines of biology, chemistry, geography and physics (figure 1). Within the framework of these disciplines, conducting integrated classes of the first and second types. Conducting other types of classes requires significant preparation and delivery resources. Therefore, their use is possible during periods of educational and pedagogical practice or in disciplines of free choice.

In the curricula of specialties among the disciplines of free choice, there are courses that allow creating an integrated short-term project activity. As can be seen from the presented diagram (figure 1), integrative courses comprise more than twenty academic credits in the block of disciplines (S). Here is a list of such courses:

- Natural-scientific picture of the world
- Concepts of modern natural science
- Simulation of "smart" IoT devices
- STEM education of science teacher
- Trends in energy and resource conservation in the modern world
- Modern information technologies and technical teaching aids
- Modeling and forecasting the state of the environment
- Computer modelling
- Electrical engineering
- Fundamentals of engineering and technology
- Material and technical support of natural sciences
- Statistical methods in natural sciences
- Information technology and technical training aids

These disciplines integrate the knowledge of mathematics and science training. The modern technologies use allows modernizing the approaches to teaching basic disciplines and disciplines of a professional direction. Most of these disciplines belong to the selective block; students are given the opportunity to choose an area of research that is interesting for them. The presence of such disciplines as Computer Modeling, the Internet of Things ensures the construction of the educational process in accordance with the criteria of integration and innovation, since these courses should be at their core. Each of these disciplines is responsible for the process of research, innovation and social development of future professionals, in particular, future science teachers.

On the basis of the conducted researches we made the SWOT-analysis of prospects of preparation of future teachers of the integrated course "Natural sciences" (figure 2).

Increasing attention to the future teachers training to teach integrated courses solves several tasks:

- ensuring the quality of natural sciences and mathematics teaching;
- be aware of innovations and independently build the teaching of the subject using modern technological and engineering knowledge with the help of modern technological means;
- creating conditions for the development of secondary education students' interest in the study of natural and mathematical sciences, technologies;
- involvement of young people in the study of exact sciences and achievements in STEM direction;
- organization of schoolchildren for research and management using innovative technologies;
- preparation of the person for the decision of global questions with application of technological decisions in the course of training and being based on innovations in the field of technologies;
- opportunities to identify trends in the modernization of world technologies and their impact on educational activities;
- dissemination of innovations and knowledge about them in the professional circle and use in everyday life.

To ensure their successful implementation, teachers of natural sciences and mathematics are needed, who themselves would be the bearers of the ideology of these changes, as well as have the necessary competencies in STEM education. Therefore, in accordance with the new educational requirements, the professional training system of natural sciences and mathematics future teachers should change, in particular in terms of their preparation for the use of STEM technologies in future professional activities. A comprehensive solution to these challenges is possible only with a systematic approach to the introduction of STEM technologies in the educational activities of future teachers.

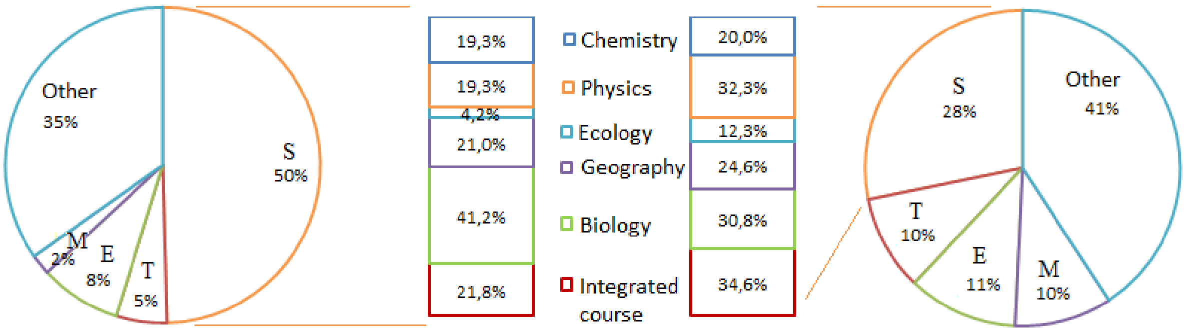

Figure 1: Percentage of subjects of specialization “Natural Sciences” in educational programs.

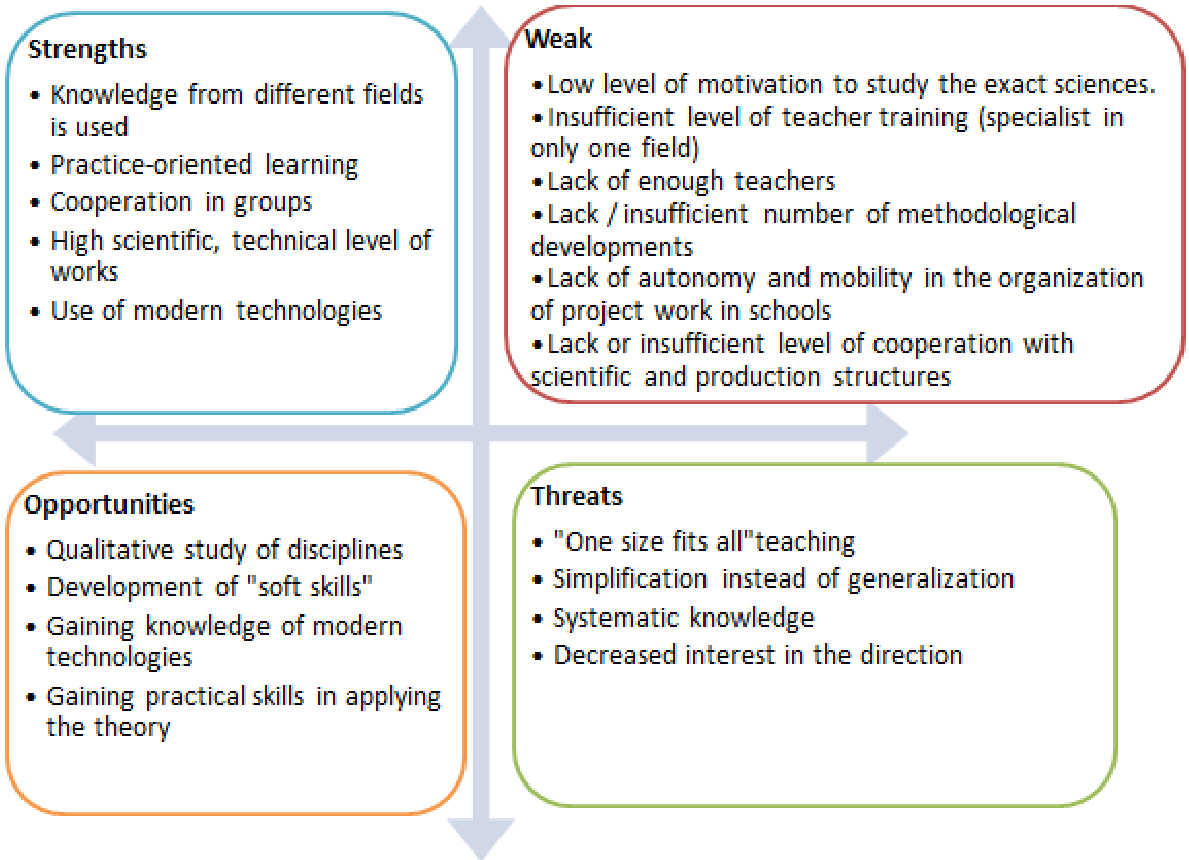

Figure 2: SWOT-analysis of STEM education implementation.

3 CONCLUSIONS

The curricula analysis of specialties of the course Natural Sciences allowed to establish that in educational programs of these specialties integrativity is provided both in the form of separate disciplines, and in a course of disciplines of a methodical cycle. Educational programs partially take into account the scientific and technical level of development of the modern world, creating disciplines of innovative content, such as “STEM teacher education” etc. The SWOT analysis helped to establish that in order to ensure quality future teachers training of integrated courses, it is necessary to focus on creating sufficient resources and infrastructure of the educational institution; ensuring equal access and involvement in integrated learning; training of teachers who will teach integrated courses. The study will further build the curriculum of integrated disciplines with a balanced presentation of materials and taking into account the innovative content.

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Formation of Information Culture of Vocational Education Specialists

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Keywords: Vocational Education, Specialists, “Digital Technologies”, “Sphere of Service (Tourist Service)”, Information Culture.

Abstract: This article reflects the system of multilevel continuing professional teaching of vocational education specialists. The basic principles of this process are investigated and the structure of training of vocational education specialists is determined by means of the analysis of the state standards of preparation of graduates in a specialty “Professional education”, educational programs and curricula. There is made comparative analysis of the maintenance of preparation of graduates of a specialty “Professional education” on specializations “Digital technologies” and “Sphere of service (Tourist service)” for formation of their information culture.

1 INTRODUCTION

Main peculiarities of modern society is informatization of all spheres of human life: from simple document management to solving complex production problems (Fedorenko et al., 2019). Herewith, of great importance is the interaction of all members of society with various computer technologies for information processing. However, the average level of computer training of the adult population today is insufficient to meet the growing needs of both production and service. The modern labor market, which was being intensively transformed in the conditions of a pandemic, puts forward new requirements to the content and process of professional training. After all, today the employer needs a specialist who has deep knowledge not only in the field of professional activity, but also in information technology. In modern education, it is unthinkable to train professionals who cannot using information technology. At the same time, the specificity of computer technologies lies in their intensive dynamics of development: every five years the technologies are significantly updated, new opportunities for high-speed data access appear, new applications with convenient functionality for almost every employee (Lehka and Shokaliuk, 2018). This explains the fact that in higher education institutions, the training of specialists for the using of information technology always lags behind the needs of practice, and this creates a certain disparity in society (Asherov et al., 2005).

2 LITERATURE REVIEW

Note that the training of professionals capable of professional and production-technological activities is a priority area of development of higher education and requires special attention from the state and the proper use of information technology in the educational process has significantly affected the higher education system in general and professional in particular.

Thus, we believe that today it is not enough to form the ICT competence of specialists, or “skills of the use of information and communication technolo-

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gies" (Ministry of Education and Science of Ukraine, 2019), or "the ability to search process and analyze information from different sources" (Ministry of Education and Science of Ukraine, 2020). This is not enough for a specialist who will work in the post-industrial information society and such a task cannot be solved by studying one or two computer science disciplines. We need to talk about something much more voluminous in the essence and content – the information culture.

Despite numerous studies of the concept of "information culture", most scientists analyze it from the standpoint of individual sciences, which limits the vision of this phenomenon in modern society. The first attempts to analyze the genesis of information culture, to identify its historical and social conditionality were made in (Curry and Moore, 2003; Khan and Azmi, 2005; Labouitz and Tamm, 1987; Leonhardt, 1988; Lubar, 1999; Metz, 1986; Mordue, 1995; Oliver, 2004; Porter, 1995; Rubanov, 1989; Szecskö, 1986; Travica, 2005; Welsch, 1989; Widén-Wulff, 2000; Zambare, 2003). The formation of information culture at various levels of education were studied in (Abitova et al., 2020; Almazova et al., 2018; Babenko, 2018; Boamah and Salahshour, 2021; Ibashova et al., 2017; Lauri et al., 2021; Lepik and Kannukene, 2018; Mullins, 2019; Virkus and Salman, 2020).

The main components of information culture by Karagodov (Karagodov, 2000) include:

- information (computer) literacy;
- information competence;
- information value-content component;
- information reflection.

Information competence and information literacy were considered by Karagodov (Karagodov, 2000) to be key, because they provide a procedural component of human information activities, form a certain value attitude to knowledge, and are the basis for information culture.

According to (Kyrychenko, 2016), "the information culture of the individual is formed in the process of socialization in its broadest sense. Basic competencies that are part of the structure of information culture of the individual are formed under the influence of a wide range of factors of the social environment, not limited to the training process and labor training conditions within specific professions, which until recently were associated with direct functional use of ICT".

Under the "information culture of the educator" Ramsky (Ramsky, 2013) perceives "an integral indicator of the level of his perfection in the information sphere of activity, which is manifested in the specifics of pedagogical activity and the system of professional qualities". In the information culture of the individual (as well as in the information culture of the educator), he identified the following interrelated components: information and intellectual potential, information worldview, information values, information needs, information and operational activities.

Klimenko (Klimenko, 2006) identified in the content of the concept of "information culture such important elements as the ability to use information technology, computer literacy; knowledge of information and information environment; ability to work with information; to build their information activities and behavior in a post-industrial society". However, it should be noted that there is a "contradiction in understanding the essence of information culture in pedagogical sciences, which is confirmed by representatives of this field of knowledge, who note that the formation of information culture of future specialists is often considered on the basis of a monodisciplinary approach in such areas: basics of library and bibliographic knowledge; reading culture, basics of rational work with the book; basics of informatics and scientific and technical information; computer technology and basics of computer literacy" (Stepanov, 2012). Important components of the information culture of the tutor are: "information knowledge and skills of the user to use a personal computer, peripherals; mastering the skills of working with software, using application programs to search, process and transmit information; information knowledge and skills of the tutor, which include knowledge of sanitary conditions and modes of safe use of computers in the educational process; formation of professional skills in the development and implementation of teaching materials; mastering educational software; ability to education and self-education" (Kuzemko, 2016). Attempts to overcome such a narrow understanding can be found in theoretical works in the field of pedagogy: for example, Galeta (Galeta, 2011) notes: "information culture today is still mainly an indicator not of general culture in its socio-technical aspect, but professional. The ability to work with information technology was often combined, at best, with knowledge of computer science, mathematics and English, scilicet those areas that provide practical human interaction with the technical means of obtaining and providing information. However, when looking at information culture more broadly, it should be noted that general methods of providing knowledge and skills should not be sought only within a computer situation. The real limits of the application of information culture are much wider; the range of its content is much richer".

Analysis of approaches to the essence of information culture, formed in philosophy, culturology, economics and other fields of knowledge, allowed Belyakov et al. (Belyakov et al., 2018) to see that understanding of this phenomenon in different sciences has its differences due to the influence of system-forming categories of these sciences, and the tasks set by the researchers. Common to the above approaches is the understanding of information culture as a component of general culture in society, as well as the recognition of determinative links between the level of information culture and the development of a particular area of professional activity of the individual. Differences in the perception of the studied phenomenon concern the wide or narrow coverage of the features of information culture: from the skills of mastering certain information technologies (computer literacy) to mastering knowledge and skills in almost all areas of human activity. In the first case, we obtain a set of certain characteristics that can be formed by mechanical assimilation of algorithms, without awareness of their direction and value features. In the second case, there is a synthetic combination of categories inherent in different sciences, which greatly complicates the possibility of studying the features of information culture.

In our opinion, information culture is a complex formation of information worldview (system of human views on information), information literacy (system of skills to work with information) and literacy in the field of information and communication technologies (actually, ICT competence).

Levels of manifestation of information culture:

- target – a person's need to receive relevant, reliable information and interest in it;
- cognitive – knowledge and ability to apply them;
- value – evaluation of information, attitude to it, own judgments and interpretations;
- behavioral – a reaction to the received information.

Thus, information culture is a system of material and mental means of realizing the relationship between people, society and the information environment, which was formed in the process of informatization of society.

Information culture in higher education institutions is implemented as a system of multilevel information technology training of future professionals in vocational education, which is based on the principles of continuity, continuity and sufficiency of informatization of the educational process, integration of special and information disciplines, formation of professional information environment and single information space in institution of higher education (Nikolaenko, 2006). Therefore, we can consider it the most important factor in successful professional activity and security of the graduate in the information society.

3 RESULTS

The aim of the work was to analyze the training of future professionals in vocational education in higher education institutions in the context of studying the prospects of forming their information culture.

First of all, let's find out what specializations future specialists in vocational education can acquire and what qualifications to get. According to the order of the Ministry of Education and Science of Ukraine No 292 from 21.03.2016 "On approval of the List of specializations for higher education in specialty 015 Professional education (by specializations)", which is the formation and placement of the state order there were 22 specializations, but after implementation of the order of the Ministry of Education and Science of Ukraine No 1223 from 23.09.2019 "On amendments to the order of the Ministry of Education and Science of Ukraine from 21.03.2016 No 292" (Ministry of Education and Science of Ukraine, 2016) there are only 9 left:

015.31 Construction and welding;

015.32 Electronics, metrology and radio telecommunications;

015.33 Power engineering, electrical engineering and electromechanics;

015.34 Mechanical engineering;

015.35 Mining, processing and transportation of minerals;

015.36 Technology of light industry products;

015.37 Agricultural production, processing of agricultural products and food technologies;

015.38 Transport;

015.39 Digital technologies.

Of course, higher education institutions in the conditions of autonomy have the right to train specialists in other educational programs, but public funding was provided only for these, which accordingly contributes to the professional orientation of entrants and ensuring competition for these specializations.

As for the analysis of the qualification that will be obtained by graduates of these specializations, we turn again to the standards of higher education at the first (Ministry of Education and Science of Ukraine,

2019) and second (Ministry of Education and Science of Ukraine, 2020) educational levels, we find only the educational qualification “Bachelor / Master of Vocational Education (by specialization)”.

The objectives of training in the standard of training of bachelors are specified as training of specialists capable of carrying out educational activities on professional training of technical specialists, skilled workers and workers in trade and services (according to the Classifier of professions 003:2010 (hrliga.com, 2010)) areas according to specialization. The objectives of training in the standard of master’s training were defined as follows: training of specialists capable of solving complex problems and problems of specialization of vocational education in professional activities and / or in the learning process, which involves research and / or innovation and uncertainty of conditions and requirements. Also for masters the field of professional activity is more clearly defined, where the graduate of educational programs in the specialty can work according to the Classifier of professions 003:2010 (hrliga.com, 2010) and the International Standard Classification of Occupations 2008 (ISCO-08) (International Labour Office, 2012): 23 Teachers; 235 Other training professionals; 2351 Professionals in the field of teaching methods; Professionals in the field of relevant specialization.

Given the above information, it becomes clear that a graduate of this specialty at the first (bachelor’s) level must be ready to work in institutions of professional, vocational, professional higher and higher education in the following positions:

3340 Other specialists in the education: teacher-trainee; educator; dormitory educator; educator of vocational school; industrial training instructor; instructor of industrial training of workers of mass professions; laboratory assistant; master of industrial training; master of the training ground; master of the training center; methodologist for vocational rehabilitation; tutor of professional training.

A graduate of this specialty at the second (master’s) level must be ready to work in institutions of professional, vocational, higher professional education and higher education in the following positions:

- 2310 Tutors of universities and institutions of higher education: assistant, tutor of higher education;

  2320 Tutors of general secondary education institutions: tutor of a vocational school, tutor of a vocational institution;

  2350 Other professionals in the education: tutor (teaching methods), educator-methodologist, methodologist.

As for the engineering component of the educational program and the qualification itself, in terms of current trends in vocational education at all levels and the focus of educational programs on dual training, which provides for coordinated interaction of the educational and industrial spheres for the training of qualified personnel of a certain profile within in organizationally – different forms of training (Ministry of Education and Science of Ukraine, 2018), it should be left for this specialty and integrated into the system of training a specialist who is able to work both directly in the workplace and in the educational institution in the relevant positions. After all, unlike the profession of “teacher”, which provides for the teaching of fundamental sciences in the content of relevant school subjects at the academic level, “tutor of professional, vocational and technical higher education” must carry out the educational process taking into account the profile of specialties. The person who teach, should provide professionally oriented training of higher education students of such institutions, and therefore its training should be appropriate: both production and pedagogical.

Taking into account the basic principles of higher education development in Ukraine within the Bologna process, as well as the specifics of professional training, we offer a scheme of educational process based on fundamental and psychological-pedagogical training with a dynamic model of professional disciplines (figure 1).

Figure 1: Structural scheme of training future specialists in vocational education.

Ensuring quality training of future specialists in vocational education involves the gradual implementation of this scheme. The whole process was divided into separate levels, at each of which the disciplines of certain cycles are studied, according to the principle that at the end of each level the applicant receives a certain amount of basic knowledge with their further expansion and deepening at the next stage.

In our opinion, the content of training of future professionals in vocational education should be based on the following principles:

- formation of information culture of the specialist, appropriate to the current level and prospects of information processes and systems, which is possible only with the integrated using of modern technologies in the educational process of higher education, as a set of three interrelated components – objects of study, tools for professional disciplines and practical training with the use of new educational technologies;
- basics of information technology (office programs: text and spreadsheet editors, programs for creating presentations; graphic editors; Internet technologies; database management systems), information systems architecture and system software; elements of programming and the Internet of Things should be studied by applicants for higher education in the form of professionally oriented courses, taking into account the profile of future professional activity;
- in the content of information training should be distinguished invariant part, which includes fundamental methodological knowledge studied in lectures, and a variable, dynamically changing part related to computer software and hardware, and studied in practical and laboratory classes;
- to increase the professional competence of the graduate in the field of information technology in the curriculum it is necessary to introduce disciplines focused on the professional orientation of future professionals in vocational education;
- for the implementation of individual educational trajectories in the curriculum should provide disciplines of the information cycle, taking into account the different levels of computer training of higher education, as well as the area of future professional interests;
- computer-oriented educational technologies used in the educational process should be rationally combined with traditional technologies of higher education and supported by modern technical means.

Thus, the training of future professionals in vocational education involves a combination of knowledge in the field of information technology with the ability of their methodological application in the pedagogical process. Consider the implementation of the developed structural scheme of training a future specialist in vocational education (figure 1) on the example of subject specialization: “Digital Technology”, where information technology is both a means of learning and a subject of study from the standpoint of the profession.

A feature of the specialization “Digital Technology” is the rapid changes in the content of educational disciplines of professional and practical training, which is associated with the intensive development of computer technology and information technology. Since professional (engineering) training is important in the formation of future professionals in vocational education, we will focus in more detail on the disciplines that determine its professional orientation (figure 2).

The first level of training of future professionals in vocational education is based on the study of disciplines of the fundamental cycle, where special emphasis is placed on “Introduction to Informatics – Information and Communication Technologies”, “Higher Mathematics”, “Computer Physics”, ”Software” and forms the basis for the transition to professional training starting from the first semester.

Knowledge of document automation and means of graphical presentation and data editing is required for presenting information using information technology. These tasks are solved in the course “Software”. The course considers the basics of computer data processing using Microsoft Office. In addition, fundamental knowledge of computer layout based on PageMaker and the ability to work with vector and raster graphics (Corel Draw, Photoshop) were formed here.

After completing the first level of training, a significant number of applicants for higher education (over 80%) use the possibilities of information technology in the process of self-study of disciplines of professional and practical training, in particular, in the process of individual research tasks, coursework and more. At the same time, the previously acquired skills of working with applied and tool products, information resources of the Internet find practical application.

The second level involves the study of disciplines: “Application and Web Programming”, “Operating Systems and System Programming”, “Computer Graphics”, “Computer Systems Hardware”, “Computer Aided Systems”, “Software in Production”, the purpose of which is to form professional competencies in understanding and using information technologies. “Application and web programming” involves mastering modern, object-oriented methods of working in Visual Studio, as the most common and uni-

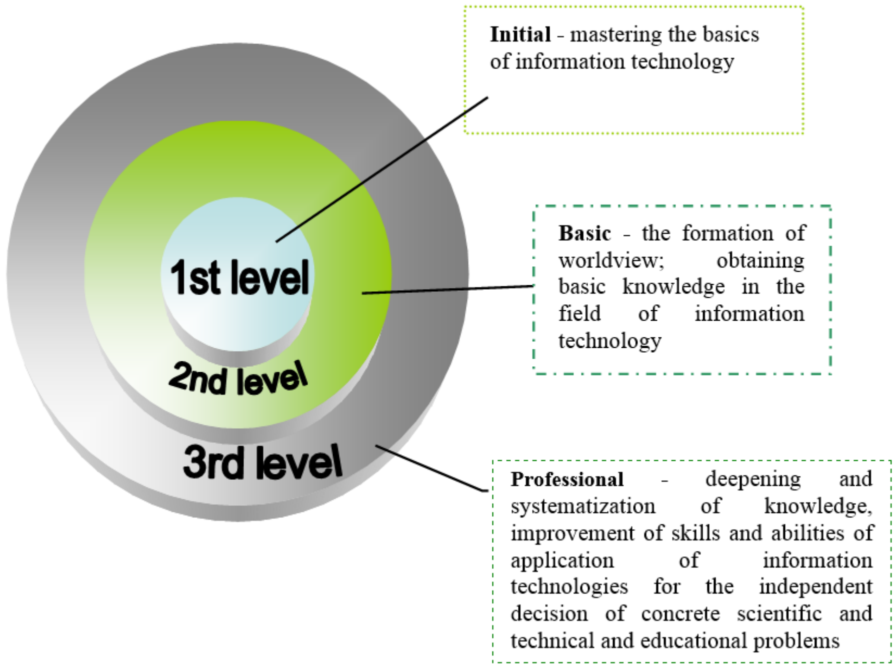

Figure 2: Comparative formation of professional training of future specialists in vocational education.

versal package of programming environments. The main purpose of the discipline “Operating Systems and System Programming” is to acquire knowledge about modern operating systems Windows and Linux, the principles of their structure, operation and administration. These disciplines form in future professionals in vocational education the ability to design and operate the most common currently operating systems, using elements of programming. This allows integrating the study of computer science, eliminating elements of tautology in the presentation of the material, as well as using information technology to solve applied problems. In addition, knowledge of these subjects was consolidated when solving problems in the Mathcad system, as well as the WinMachine software package.

At the same time, the discipline “Methods of professional training” is studied at the second level. The purpose of the course is to deepen engineering, technical, psychological and pedagogical knowledge and skills and also their integration and provide opportunities for the formation of a holistic phenomenon – information culture, both from the standpoint of engineering and from the standpoint of pedagogical training.

Examples of dynamic integration are the disciplines that form the visual and design basis of engineering training, in particular: “Descriptive Geometry”, ”Engineering Graphics”, “Computer Graphics”. Having received at the first level an idea of the image of spatial objects on the plane, at the second level knowledge in the field of geometric, machine-building and construction drawings with the subsequent application of computer technologies (graphic editor Compass-Graph, AutoCAD, SolidWorks, etc.) is formed.

At the third – professional level – training of future specialists in vocational education is differentiated. Depending on the specialization, the profile disciplines were taught, which deepen and systematize the knowledge obtained at the first two levels in relation to the chosen direction of professional activity.

At this level, the formation of skills for independent solution of scientific, technical and educational problems becomes important. That is why a course project was implemented here, which integrates the disciplines of fundamental and professional training and provides for the implementation of tasks that actually appear in the production or management field. Practical classes are held more in the form of discussions and trainings, which also contributes to the formation of a specialist who is able to make independent decisions, work in a team, formulate and convey the necessary knowledge to other individuals.

Given that information technology is rapidly updated and partially modified, at the final level the disciplines that are most dependent on such trends are studied, namely: “Information security in computer networks”, ”Intelligent systems and technologies”, “Web technologies and web design”.

Disciplines of professional orientation are based on mastering the software which is universal from the point of view of studying of the planned educational material and, besides, allows to form design thinking. We are talking about the WinMachine software package, Matlab and Compass environments, which are currently the most promising.

As for the processes of formation of information culture of future specialists in vocational education of other specializations, where computer science disciplines are much less, we want to analyze their content on the example of specialization “Service (Tourism)”.

The first level of training of future specialists in vocational education specialization “Service (Tourism)” is implemented on the basis of studying the disciplines of the fundamental cycle, with special emphasis on ”Introduction to Informatics – Information and Communication Technologies”, ”Mathematics for Tourism”, “Physics”, which generally resembles the first level of the previously analyzed specialization “Digital Technologies”. After studying these disciplines, higher education students have formed a basis for the further formation of information culture and readiness to use computer technology in the study of other disciplines of professional and practical training.

The second level involves the study of the discipline “Methods of using computer technology in the study of professional disciplines”. At the same time, the discipline “Methods of professional training” is studied at the second level, thanks to which it is also possible to form technical and psychological-pedagogical knowledge and skills in an integrated form and to provide preconditions for the formation of information culture.

At the third professional level the discipline “Information systems and technologies in tourism” is studied, the main purpose of which is to form and develop professional competencies in the use of information technology in professional activities. However, it should be noted that tutors of geographical and environmental disciplines regularly use information technology in their classes, which provides a dynamic development of information culture of future professionals in vocational education specialization “Service (Tourist Services)”. That is, depending on the specialization, the profile disciplines are taught, which deepen and systematize the knowledge obtained at the first two levels in relation to the chosen direction of professional activity.

During the implementation in the educational process of the proposed method of forming the information culture of future professionals in vocational education to diagnose the level of formation of information culture of future professionals in vocational education in specializations “Digital Technologies” and “Tourist Services” was conducted testing information culture of students at the following levels:

1 – initial (D, E),

2 – basic (B, C),

3 – professional (A).

Lets consider the results of comparing of the two samples (for specializations “Digital Technologies” and “Tourist Services”) regarding to the level of formation of their information culture.

The analysis of test results showed that the basic level of information culture of future professionals in vocational education in the specialty ”Digital Technologies” only 5.9% higher than the level of students specializing in “Tourist Services” and the professional level - by 5.7%. Figure 3 shows a summary of the results, which indicate that we have developed a method of forming the information culture of future professionals in vocational education in the specialties “Digital Technologies” and “Tourist Services” is within acceptable margin of error.

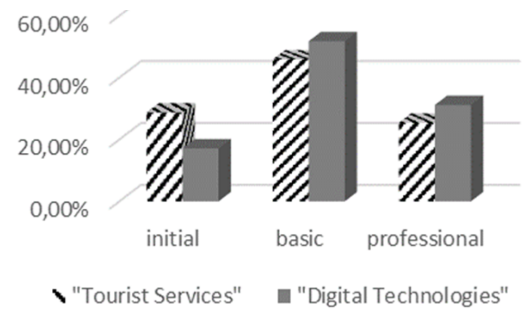

Figure 3: The level of formation of information culture of future professionals in vocational education.

Statistical significance of differences in the levels of student achievement and substantiation of hypotheses, which were put forward to determine the differences between the distributions of students in the control and experimental samples was carried out using the Pearson test (χ^2). The choice of this technique was due to the fact that the criterion χ^2 applies to samples with a large number of respondents and allows on the basis of comparing the values of the calculated χ^2_{exp} and tabular for critical values χ^2_{tab} to conclude a significant or insignificant difference in the distribution of respondents sign (the level of formation of their information culture). The technology of the method assumes that the greater the difference in the values of χ^2_{exp} and χ^2_{tab}, the more significant are the differences between the distributions in the samples. We compare these distributions statistically in

Table 1: The level of formation of information culture of future specialists in vocational education.

Groups	Level of academic achievement					
	initial		basic		professional	
	students	in %	students	in %	students	in %
"Tourist Services"	52	28.7	83	45.9	46	25.4
"Digital Technologies"	34	17.1	103	51.8	62	31.1

order to identify differences in the levels of academic achievement of students in control and experimental groups and determine their statistical reliability.

For the initial and alternative hypotheses we take the following statements:

H_0: the difference in the achieved levels of formation of the information culture of the groups is insignificant and invisible at the level of significance of 0.05;

H_1: the level of formation of information culture of these groups in both cases differs and this difference is statistically significant with a probability of 0.95.

We calculate for each discipline Pearson's criterion χ^2_{exp}, using the formula

$$\chi^2 = \sum_{i=1}^{n} \frac{(x_i - y_i)^2}{y_i}$$

For $P = 0.95$ and $q = 2$ (q is the number of degrees of freedom; $q = n - 1$, where n is the number of evaluation levels – in our case $n = 3$) the critical value $\chi^2_{tab} = 5.99$ (according to the table of critical values).

It turned out that $\chi^2_{exp} = 0.07$ does not exceed the critical, which confirms the effectiveness of the proposed method of forming information culture specialists in vocational education of both samples of specialists in vocational education in the specializations "Digital Technologies" and "Tourist Services".

4 CONCLUSIONS

Thus, the multilevel system of information technology training in higher education is the single integrated complex, the main task of which is the practical implementation of information technology at all stages of study at the university and in the further professional activities of future specialists in vocational education.

The use of information technology should be scientifically sound, have a methodological basis that will allow asserting the formation of information future professionals in vocational education.

In the process of learning, higher education students must obtain a certain system of knowledge, which consists not of separate courses, but of complex, integrated disciplines that cover certain areas of professional training.

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The Use of Serverless Technologies to Support Data Processing within the Open Learning and Research Systems

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Keywords: Cloud Computing, Serverless Technologies, Open Science.

Abstract: The article highlights the promising ways of providing access to cloud-based tools using serverless solutions to support data processing within the open learning and research environment. It is emphasized that the implementation of serverless technologies is a current trend in the development of modern ICT open learning and research systems. The concept of the hybrid serverless cloud is considered. The analysis and evaluation of the existing experience of using different types of cloud-based solutions to data processing support are considered and evaluated. The example of the wave files processing using the lambda-function is examined. The issues of integration of different services within the open systems of learning and research are covered. A concept of the cloud-based open learning and research university environment involving the use of the serverless cloud-based components is considered. The reasonable ways of tools selection are evaluated and the prospects for their use within the cloud-based open learning and research environment are described.

1 INTRODUCTION

The formation and development of a cloud-based learning and research environment, taking into account the principles of open science is an important area of modernization of the educational process in higher education, the leading trend in the development of pedagogical systems of open education within the European Research Area (ERA, 2015). Thanks to the use of cloud technologies there is an opportunity to build more convenient, flexible, scalable systems for access to electronic resources and services in the process of learning and research, creating conditions for teamwork with software applications along with the removal of geographical and time constraints, providing mobility of all subjects (Bondarenko et al., 2019; Bykov and Shyshkina, 2018; Bykov et al., 2020). This creates a basis for the implementation of the principles and technologies of open science for a wider range of users, the creation and operation of virtual research teams, improving scientific communication processes, access to data in the research process, implementation of their results, interaction with society (www.fosteropenscience.eu, 2019). Cloud computing tools and services form an information technology platform of the modern educational and scientific environment, becoming a network tool for the formation of this environment (Bargmann, 2018; Hevko et al., 2021; Markova et al., 2015; Mazorchuk et al., 2020; Munk et al., 2020; Roberts and Chapin, 2017). Thus, it becomes relevant to analyze trends in the implementation of cloud data processing services into the activities of a scientist and also the research or educational institution.

2 THE RESEARCH RESULTS

2.1 The Background Issues

Cloud computing in several kinds of available models, such as IaaS, PaaS and SaaS, plays an important role in facilitating learning and research data processing. Providing abstraction of resources and simple automation tools, modern cloud platforms simplify most routine tasks such as installation, maintenance,

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backup, security, and more (Bykov et al., 2020; Svetsky et al., 2017). Moreover, today, the concept of open science deals with open data and big data processing. To fit the requirements of open science systems design large amounts of data are to be available for users access and joint processing. Thus the cloud computing platforms may serve as a reasonable framework to support open learning and research processes both in terms of maintaining and processing a large amount of data and also to make it available for the community of scientists for joint processing, retrieving and evaluation (Bykov et al., 2020).

The computing capacity becomes crucial for large amounts of data processing and retrieval, as this kind of activity is needed at most stages the research process, such as data collecting, representation, visualization, analysis, interpretation and discussion. The possible way to save resources and to provide flexible use of the cloud-based infrastructure is using lambda-function within the serverless settings. This leads to the notion of Function-As-A-Service (FAAS) as a promising available cloud-based model (Roberts and Chapin, 2017; Bargmann, 2018; Jonas et al., 2019; van Eyk et al., 2018).

The serverless computing applications in different areas and their estimation are among the most current issues considered nowadays, for example for machine learning (Kurz, 2021), network functions virtualization (Aditya et al., 2019), geospatial architectures (Bebortta et al., 2020). Casale et al. (Casale et al., 2020) propose the platform for decomposition and orchestration for serverless computing. Ortiz (Ortiz, 2019) present architecting serverless microservices on the cloud with AWS and also issues of instructors training to use these technologies. Still the area of educational application of serverless technologies to provide better use and implementation for learning and research within the university sector is poorly investigated and needs further research. There is a need to consider methodological issues and possible ways of serverless technology application within the open learning and research university environment.

The article aims to consider and evaluate a hybrid cloud-based serverless architecture as the possible open learning and research platform to support data processing and research collaboration. The main idea is that design and development of learning and research environment due to the proposed approach will result in more efficient use of the cloud-based resources, better access to learning and research data and collaboration support. The case study of the sound signal processing as possible example of serverless approach application for learning and research is considered.

2.2 The Conceptual Basis

The conceptual and terminological body of investigation and the main principles of designing and developing university cloud-based learning and research environment such as the principles of open science, open education, as well as the specific principles inherent in cloud-oriented systems are considered by Bykov and Shyshkina (Bykov and Shyshkina, 2018).

The cloud-based learning and research environment (LRE) of a higher education institution is the environment in which the virtualized computer-technological (corporate or hybrid-based) infrastructure is purposefully built for the realization of computer-procedural functions (such as content-technological and information-communication functions) (Bykov and Shyshkina, 2018).

Serverless technologies are used to build applications that are hardly predictable as for the amount of the computer capacities necessary for their processing. The serverless hybrid cloud architecture is designed to deploy the lambda-functions (aws.amazon.com, 2019).

The lambda-function is a cloud-based service model when the computing is fulfilled within the cloud-based infrastructure of a provider on user demand and the user needn't create and manage the server architecture.

2.3 The Model and Approach

In figure 1, the configuration of the serverless application architecture is shown.

The overall approach is to access Lambda-function trough API Gateway, avoiding server management as Lambda-function returns the values into the static HTML format, the data retrieved on S3-basket, that may be outputted and processed.

In this case, a user refers to certain electronic resources and a computing capacity set on a hybrid serverless architecture from any device using the Internet connection.

The advantage of the proposed approach is that, in learning or research processes, it is necessary to use computing capacities for special purposes that may appear eventually due to the current need. In particular, in the course of the experimental research, big data processing may be needed that require much computer capacity for a short period. It may be redundant to maintain and manage the cloud server for these purposes. At the same time, there is a possibility of designing special lambda functions so the

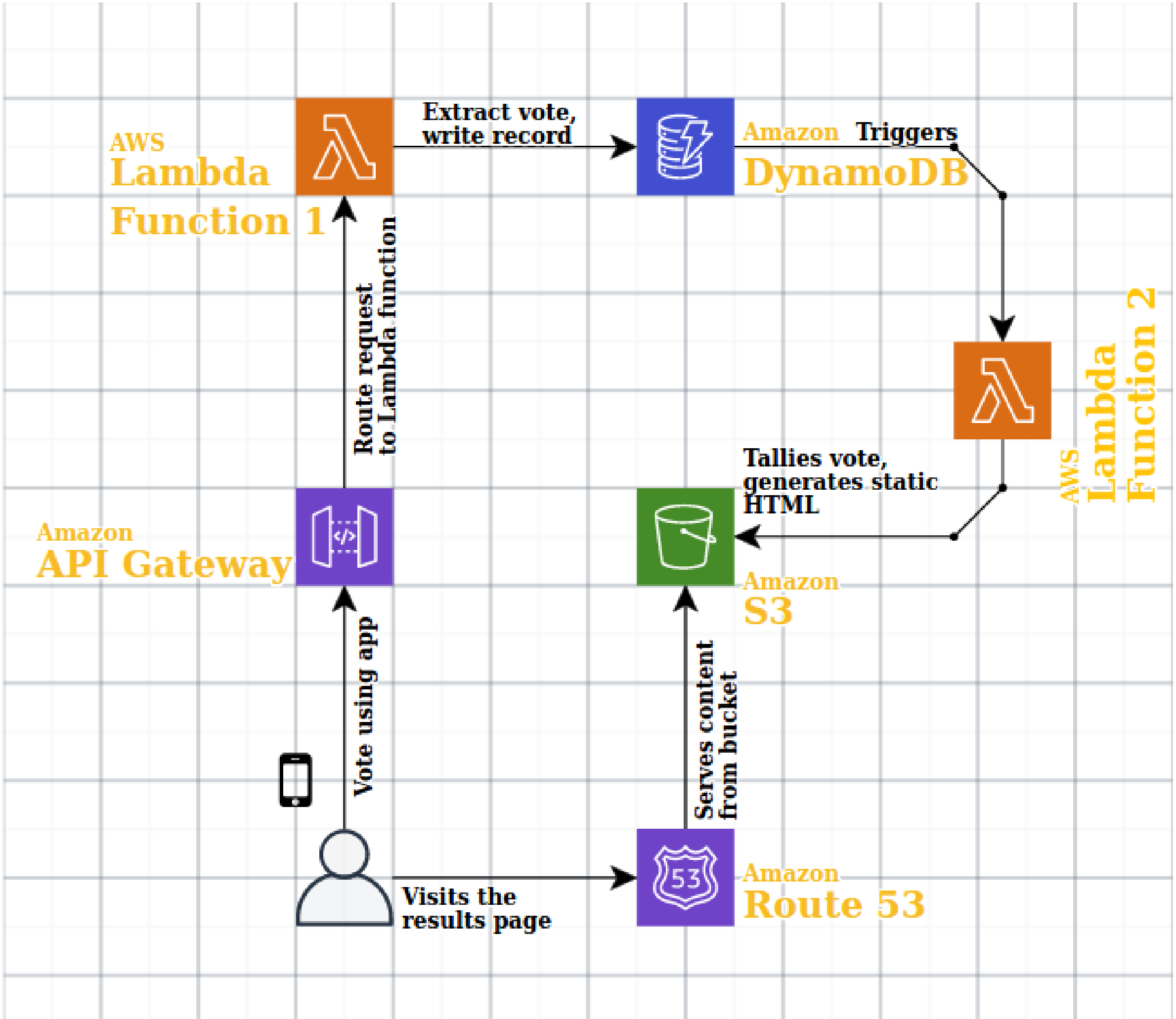

Figure 1: The serverless application architecture (retrieved from https://app.cloudcraft.co/).

learner or researcher can access them via the Internet and use the server with the powerful processing capabilities without deploying it any time as the function is needed. The necessary resources can be supplied more flexibly on demand.

2.4 Current Developments and Implementation

The cloud-based LRE was implemented at the Institute for Digitalisation of Education of the National Academy of Educational Sciences of Ukraine in the course of research projects and pedagogical experiments conducted during 2012–2017. During that period, cloud-based services for open education and open science support were introduced in the research and educational process (Bykov and Shyshkina, 2018).

In 2018 the V4+ Academic Research Consortium Integrating Databases, Robotics and Language Technologies was established, which aimed to address regional issues related to EU ICT research priorities. The BOX Cloud shared work-space – the shared work-space for all partners was built on the IBM BOX Cloud for storage and transfer of documents that networked researchers' computers. Virtual machine with Windows 10 – this virtual machine is simply a shared computer with Windows 10 in the form of a remote desktop was used to support open learning and research collaboration (Bykov et al., 2020).

The cloud-based components that had been elaborated and tested within this period of research were implemented in the learning process. The learning course "Cloud Computing Technologies" was developed and introduced in National University of Life and Environmental Sciences of Ukraine for train-

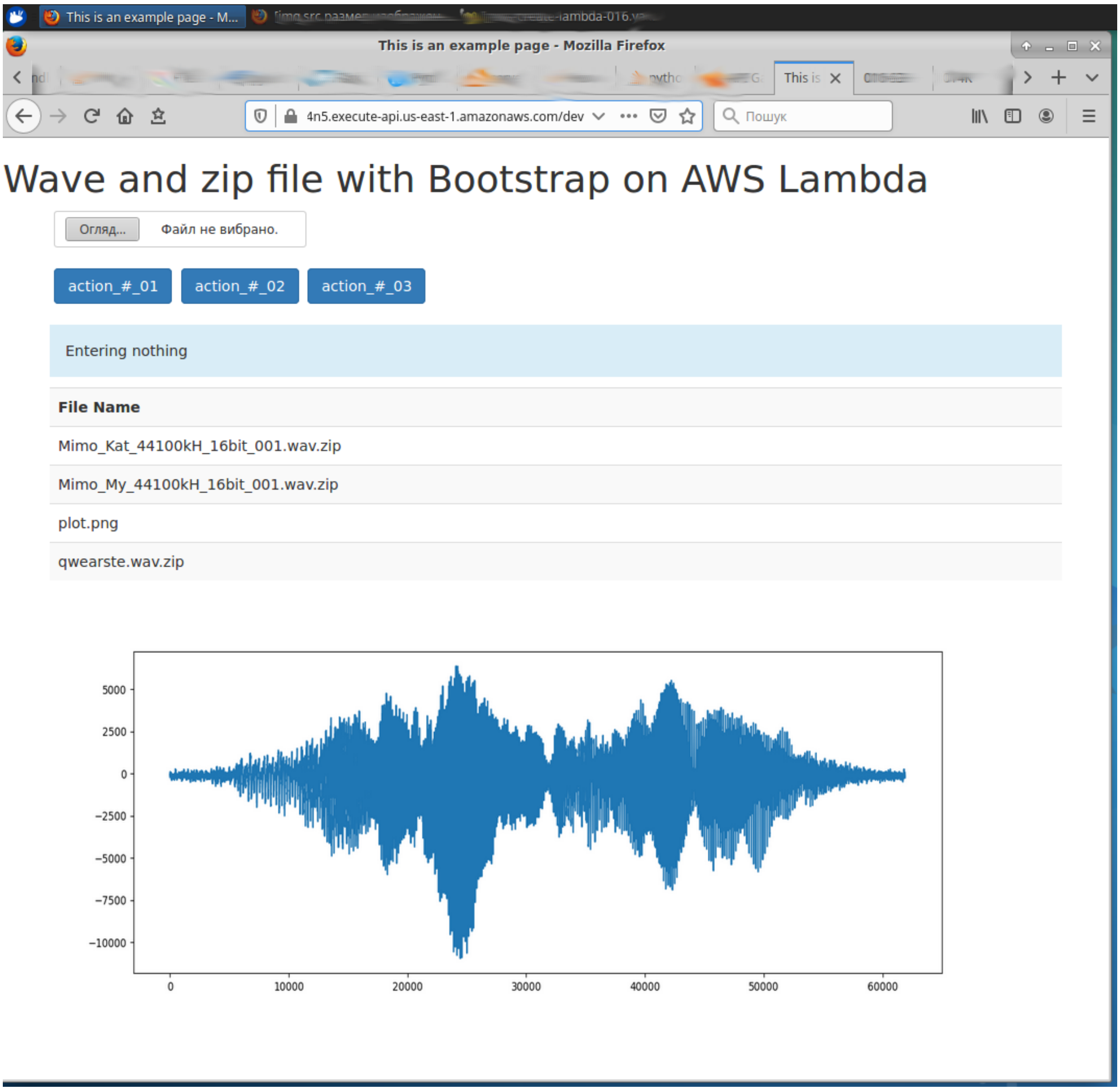

Figure 2: The result of the lambda-function processing the wave file.

ing computer science bachelors. The students were trained to build cloud-based components on virtual machines using AWS and Azure platforms. The methodology of open learning and research platform implementation proved to be useful.

The next step of the research was the creation of the serverless hybrid cloud architecture to support collaborative research with Kyiv Glushkov Institute of Cybernetics of NAN of Ukraine. The script was used for uploading and output of the sound signal oscillogram using Python programming language with the library Matplotlib within the framework Flask. The lambda-function was used to build the sound signal oscillogram and make the image (figure 2).

The serverless environment was used for the solving of tasks of wave rows analysis:

1. A Python-based Internet application tested on localhost using the Flask framework was created.
2. In the AWS console, a user account with necessary permissions to protect future applications was created. On this user account, an S3 bucket and an EC2 server were created. On S3 the working folder with the script in Python (or another working language for AWS Lambda might be used) was upload.
3. To provide the processing, it was necessary to attach one or more layers with the environment li-

braries installed. The virtual environment with the libraries was installed on the EC2 server. An additional layer was formed from this environment. Also, AWS Lambda may contain additional freely distributable layers. They can also be included in future applications.

4. The electronic table of available resources in the YAML format was formed using CloudFormation tool. The YAML script creates a separate role for working with the future application.
   4.1. Using the role, a Lambda-function was created, its codes were downloaded from the zip file created on the previous step in S3.
   4.2. Using this role a Gateway API was created allowing to call the Lambda-function from a browser.
5. Debugging was fulfilled.

Using this sequence of steps the hybrid environment with lambda-function was created and tested. Using the proposed architecture the problem of sound signal processing was solved.

3 CONCLUSIONS AND DISCUSSION

Pedagogically balanced and expedient introduction of cloud technologies in the educational and research process of higher education institutions, formation and development of the learning and research environment on this basis are factors of expanding access to electronic educational resources, increasing the effectiveness of ICT infrastructure. The use of serverless technologies to provide cloud services of data processing, visualization and retrieve is a relevant and promising area of development and modernization of the university open learning and research environment.

This experience can be used for the development of new cloud-based components for educational and scientific purposes based on the proposed architecture of the hybrid cloud-based environment with Lambda-function.

This approach still needs further implementation and evaluation.

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Model of the Competences in Educational Robotics

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Keywords: Educational Robotics, STEAM Education, Competences, Competences in Educational Robotics, Computer Science Teachers.

Abstract: The current state of development of robotics as an applied industry shows its intensive development. As a result, there is a growing demand for robotics specialists because of an urgent need for specialists to develop, design and program robots. This contributes to the popularity of robotics as an educational trend in Ukraine and around the world. The introduction of educational robotics as a part of STEAM education is a powerful step for development of students' soft skills, training for the implementation of real socially significant projects, formation of practical value of theoretical knowledge, scientific world outlook and successful life in a digital society as a whole. Taking into account the trends in the development of robotics as an applied industry and educational trend, there is a need in training pre-service teachers to make them able to teach children educational robotics. In this regard, there is the issue of determining the structure of competences in educational robotics for teachers and ways of their development. The research proves that pre-service computer science teachers are the readiest to teach educational robotics in secondary schools. The article is devoted to the issues of developing a model of competences in educational robotics for teachers, as well as their formation in pre-service computer science teachers. The effectiveness of the model of competences in educational robotics is confirmed within the process of teaching disciplines of educational robotics for pre-service computer science teachers.

1 INTRODUCTION

The current stage of science-and-technology development is characterized by the growing popularity of robotics and increasing the use of robots. Analysis of global trends in the robotics industry shows (Strutynska, 2019a):

- Growth in the production of industrial, service and domestic robots. According to *International Federation of Robotics (IFR)*, stock of industrial robots increased by 12% (about 2.7 million units) in 2019. Sales of service and domestic robots increased by 34% in 2019 and by 15% in 2020 (IFR International Federation of Robotics, 2020);
- Accelerated growth of industrial robot production in the period from 2019 to 2021 (according to IFR estimates, the rate will accelerate to 14% on average per year);
- Introduction of robotic mechanisms and complex automation of production in many areas of social activity (industry, military, space, automotive, aviation, medicine, services, domestic life, etc.);
- Development of so-called ***Smart Factories*** as one of the components of the ***Industry 4.0*** concept, the main idea of which is the development and integration of automated production, data exchange and production technologies into a single self-regulating system with minimal or no human intervention in the production process. ***Smart Factory*** is a factory where the equipment is automated and controlled by a computer. The equipment can receive feedback on the state of the object in physical space using sensors;
- Acceleration of production automation (according to research by the World Economic Forum (WEF), the ratio in the division of labor "human-robot" will be significantly changed (by 2025) towards robotics – up to 52%;
- Increasing the interest of the world's largest companies in robotic startups. In particular, in early 2014, Google has acquired eight companies en-

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gaged in intelligent robotics;

- Growing demand for specialists in the robotics industry in general, as there is already an urgent need for specialists to develop, design and program robots.

As of today, industrial robots and integrated automation of production are in demand in many areas of social activity (Morze et al., 2018b):

- *Industry* (robots for painting, welding robots, robots for cutting metal, etc.);
- *Agriculture* (agricultural robots for harvesting and picking, weed control);
- *Military industry* (military robots, intelligence robots);
- *Medicine* (microscopic robots for use in microsurgery, robots-couriers in hospitals);
- *Aircraft* (unpiloted robots-airplanes);
- *Space industry* (self-propelled vehicles based on robotic systems);
- *Service sector* (robots for help people with special needs);
- *Domestic life* (robots-vacuum cleaners).

Especially robotics play important role for agricultural needs. It is quickly becoming an exciting high-tech industry, drawing new professionals, new companies and new investors. The technology is developing rapidly, not only advancing the production capabilities of farmers but also advancing robotics and automation technology. Robots pick apples, gather strawberries, harvest lettuce and strip away weeds. Drones gather aerial images that help farmers quickly assess crop health. And robotic greenhouses are sprouting up thousands of miles away from traditional farmland regions, growing vegetables in the backyards of high-consumption urban markets. It all comes at a time when growers face a costly, long-term labor shortage and — with the global population expected to rise from 7.7 billion to 9.7 billion in just over 30 years — food demand is poised to rise significantly (Gossett, 2021).

Robots change the way we live and work. This also means that there is already an urgent need for specialists to design, construct and program robots.

Thus, the above shows the rapid development of robotics, which in turn causes the need in appropriate training of qualified professionals for this field. This contributes to the popularity of robotics as an educational trend in Ukraine and in the world.

Paper goals are: to characterize educational robotics as a trend of STEAM education; to develop a model of competences in educational robotics for teachers; to identify ways to develop competences in educational robotics for pre-service computer science teachers.

2 EDUCATIONAL ROBOTICS AS PART OF STEAM EDUCATION

STEM education is becoming one of the most important educational trends among educators in Ukraine (Midak et al., 2021; Morze et al., 2018a, 2019; Semerikov et al., 2021; Strutynska and Umryk, 2019; Valko and Osadchyi, 2021).

STEM education (**S**cience, **T**echnology, **E**ngineering, **M**athematics) is a trend in education, under the conditions of which the science component (with the use of innovative technologies) is strengthened in the curricula.

The importance of involving young people in STEM training is also shown by a research conducted in the EU in 2018 at the initiative of the World Economic Forum under the *Digital Transformation Initiative*. The research identifies seven key technologies that are projected to have the greatest impact on industrial transformation in the near future (Digital Transformation Initiative In collaboration with Accenture, 2018) (figure 1):

- *Artificial Intelligence*;
- *Autonomous Vehicles*;
- *Big Data Analytics and Cloud*;
- *Custom Manufacturing and 3D Printing*;
- *IoT – Internet of Things / Connected Devices*;
- *Robots and Drones*;
- *Social Media and Platforms*.

All these technologies are related to digital competence, technical competence and STEM. It should also be noted that 3 of the 7 above technologies are directly related to robotics, namely: *Autonomous Vehicles, Internet of Things and Connected Devices, Robots and Drones* (figure 1).

This indicates that the demand for specialists in STEM professions will continue to grow, including workers in the robotics industry. To implement this, a high-quality STEM subject training is needed (mathematics, physics, technology, engineering, programming, etc.).

However, in many parts of Europe, employers have difficulty recruiting people with the right level of STEM skills, especially IT professionals. In addition, the latest PISA (*Program for International Student Assessment*) data show that one in five 15-year-olds in

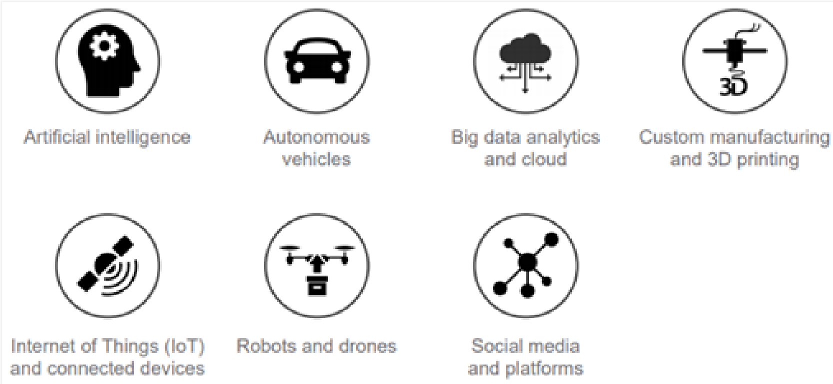

Figure 1: Technologies that transform the industry in the near future (Digital Transformation Initiative In collaboration with Accenture, 2018).

Europe is functionally illiterate in reading, math and science (Strutynska and Umryk, 2019).

One of the possible ways to involve young people in STEM subjects is to add to the exact sciences the so-called component of *Art*. Therefore, recently STEM education includes disciplines related to creativity and art, united by the general term ***Arts*** (***STEAM*** – STEM and Arts).

According to Edel (Edel, 2017), an attempt to intensify education only in the direction of science without the parallel development of Arts-disciplines may lead to the fact that the younger generation will lose the skills of creativity. For example, Massachusetts has passed legislation that takes into account not only the level of students' performance of standardized tests, but also the extent to which each school's curriculum enhances student creativity, the so-called "*creativity index*".

Robotics is one of the promising areas of modern STEAM education (Morze et al., 2018c; Osadchyi et al., 2021). Educational process with robotics provides students with the opportunity to solve real life problems that require knowledge of STEAM disciplines, in particular (Morze et al., 2018b):

- *mathematics* (spatial concepts, geometry for understanding the methods of robot movement);
- *physics* (electronics, principles of sensors operation that constitutes the basis of robots);
- *technology and design* (design of devices, parts of robots, their design);
- *ICT* (programming of robotics systems).

Nowadays, increased attention is paid to robotics as to applied science, including its educational and developmental potential. This has created a new trend in education: *educational robotics*.

Educational robotics is a crossdisciplinary area of students' learning. Its process integrates the knowledge of STEM subjects (physics, technology, mathematics), cybernetics, mechatronics, and informatics. Teaching educational robotics corresponds to the ideas of advanced training (learning the technologies that will be needed in the future) and allows students of all ages to be involved in the process of innovation, or scientific and technical creativity (Morze et al., 2018b).

In Ukraine, the development of educational robotics within the educational process occurs at the concept level, in the teaching of computer science and ICT, in extracurricular education, but for this time there is no systematic approach. Therefore, the issues of importance are the introduction of robotics in the educational process of secondary and higher education as one of the areas of STEAM education, development of appropriate curricula for students, training of pre-service teachers who will teach educational robotics, development of relevant competences in educational robotics (Strutynska, 2019a; Morze et al., 2018c).

3 COMPETENCES IN EDUCATIONAL ROBOTICS FOR TEACHERS

3.1 Components of the Competences in Educational Robotics

Preparing of today's youth to the design, programming and use of robots and robotic systems is associated with the requirements of today, namely the emergence of new professions in the field of robotics and, consequently, the need for appropriate specialists:

- operator of multifunctional robotic systems;

- robot designer (in particular designers of industrial and children's robotics, medical and home robots);
- designer of neuro-interfaces for robot management;
- designer of "smart" houses;
- unmanned aerial interface designer;
- service engineer in robotics;
- robotics programmer;
- medical robot operator;
- drone operator;
- drone engineer;
- teacher of robotics;
- builder of "smart" roads, etc.

Taking into account that robotics already plays an important role in various areas of social activity and that its role will increase in the future, it is necessary to prepare the current generation of students for this. This needs updating the content of school and university education in accordance with today's requirements. Therefore, today the issues of introduction of robotics in the educational process of higher education institutions (as a mandatory component of training pre-service teachers) are of particular importance.

The same opinion is shared by Anisimova et al. (Anisimova et al., 2020): "...the key discipline in the content of training teachers for STEAM education should be "Educational Robotics". Kushnir et al. (Kushnir et al., 2020) note that "...introducing the Educational Robotics course for future teachers is an important part of their professional training".

Thus, the development of pre-service teachers' competences in educational robotics is a topical issue of today.

Competence approach plays a special role in higher education while the training of qualified specialists. Its use makes it possible to update the content of education and ensure that education meets the needs of modern economy and civilization.

Below are the most important studies devoted to the question of determining the components of competencies in robotics, including education, their structures and models.

Eguchi (Eguchi, 2014) notes that the teaching of educational robotics contributes to the formation of pupils and students of the so-called 21 Century Skill (21 Century Skill Framework (Battelle for Kids, 2019)), which include:

- Core Subjects (English, World languages, Arts, Mathematics, Economics, Science, Geography, History);
- 21st Century Themes (global awareness; financial, economic, business and entrepreneurial literacy; civic literacy; health literacy);
- Learning and Innovation Skills (creativity and innovation skills, critical thinking and problem solving, communication and collaboration skills);
- Information, Media and Technology Skills (information literacy, media literacy, ICT);
- Life and Career Skills (flexibility and adaptability, initiative and self-direction, social and cross-cultural skills, productivity and accountability, leadership and responsibility).

Goloborodko (Goloborodko, 2012) considers robotics as a resource for the formation of key competencies, namely information, communication, educational and cognitive and competence in the field of health. Kushnir et al. (Kushnir et al., 2020) also note that "robotics helps build core competencies. This affects the formation of a scientific worldview and the corresponding system of thinking".

Morze et al. (Morze et al., 2018c) indicate that robotics classes affect the development of students' mathematical, scientific and technical competences, computer science competences, as well as social competences.

Buzhinskaya et al. (Buzhinskaya et al., 2017) define a set of competences needed for the successful application of robotics in the future professional activity of students. The most important of them (in the researchers' opinion) are development of programs for robotics management, mastery of methods of testing and debugging programs for robotics management, methods of assessing the quality of robotics management programs, etc.

In 2014–2015, a research project "Remake Learning Competencies" involve more than 100 experts in various subjects, teachers of formal and non-formal learning and program managers (Remake Learning Competencies, 2015). In the course of the research, seven working groups were created to develop different competency structures, as well as to identify cross-cutting competencies (*Cross-Cutting Competencies*).

As part of the "Remake Learning Competencies" project, a group of researchers proposed seven competency structures: *Career Readiness, Coding & Gaming, Design & Making, Media Making, Robotics, STEAM and Early Childhood Education*. Each of the developed structures consists of *knowledge, skills and abilities*.

The structure of competences in the field of robotics (proposed by the project) includes (Remake Learning Competencies, 2015):

- *knowledge in Robotics* (Circuits, Design Process, Materials & Their Characteristics, Programming Languages, Systems Thinking);
- *skills in Robotics* (Circuit Board Construction, Communication, Designing for Human-Robot Interaction, Engineering, Ethics, Fabricating, Programming);
- *dispositions in Robotics* (Collaboration).

Analysis of researches devoted to the definition and formation of competences in educational robotics shows that today there are no common approaches to developing a model of competences in educational robotics, in particular for teachers. Thus, the solution to this issue is relevant and open to research.

Analyzing the components of the above structures and models of competences in educational robotics, it should be noted that they include *components of STEAM competences*. Their inclusion in the structure of competences in educational robotics is logical, because educational robotics is a trend which integrates knowledge of many disciplines, including computer science, environmental science, mathematics, technology and others.

One of the characteristic features of educational robotics is learning through project activities. While working on robotic projects, students perform research according to the task. Thus, taking into account also the fact that research activity is a characteristic feature of STEAM subjects, *research competence* will be one of the components of competences in educational robotics.

An important component of educational robotics training is programming, which is one of the main stages of a robotics project. In addition, the design stage of a robotic system is impossible without modeling of its components, which are often performed with the use of special software. These components belong to the *digital competence*.

The formation of components of digital competence in the process of learning robotics is also mentioned in (Sedina and Soboleva, 2018). Buzhinskaya and Grebneva (Buzhinskaya and Grebneva, 2018) describe the development of ICT competence of pre-service computer science teachers in the process of teaching robotics. Thus, the individual components of digital competence will be part of the competences in educational robotics.

Competences in educational robotics, in addition to knowledge, skills and abilities, include activity and / or value-motivational components, which include critical and creative thinking, the ability to work in a team, solving complex problems, etc. A significant number of these components are characteristics and personal traits that belong to soft skills. Thus, *soft skills* (Varava et al., 2021) are also parts of the competences in educational robotics.

Thus, based on the analysis of the above groups of competences, the authors identified the components of ***competences in educational robotics***, which include:

- integral STEAM competence (in the field of robotics);
- research competence;
- digital competence;
- soft skills.

3.2 Model of the Competences in Educational Robotics for Teachers

For successful teaching of educational robotics, it is necessary to develop appropriate competences in teachers who will be able to professionally and creatively prepare students for future professions related to the robotics industry. Thus, it is necessary to add a professional-and-pedagogical component (to the considered components of educational robotics), which will include knowledge of the laws, principles, methods of teaching-and-learning of educational robotics and the relevant skills and abilities. Such a component is *methodological competence* (Mâţă, 2011).

Thus, based on the analysis of the components and taking into account the above considerations, the authors developed a ***model of competencies in educational robotics for teachers*** (figure 2).

4 PREPARATION OF THE PRE-SERVICE COMPUTER SCIENCE TEACHERS TO TEACH OF THE EDUCATIONAL ROBOTICS

Robotics is an effective means of engineering education for schoolchildren around the world. Therefore, the task of pedagogical universities is to train teachers to work with students in accordance with current trends, standards and requirements of today, including pre-service teachers who will teach educational robotics. In this regard, the following issues are becoming of high importance. Among these issues are: training students of pedagogical universities who will be able to teach children educational robotics, and, accordingly, the introduction of robotics in the educational process of higher education institutions as

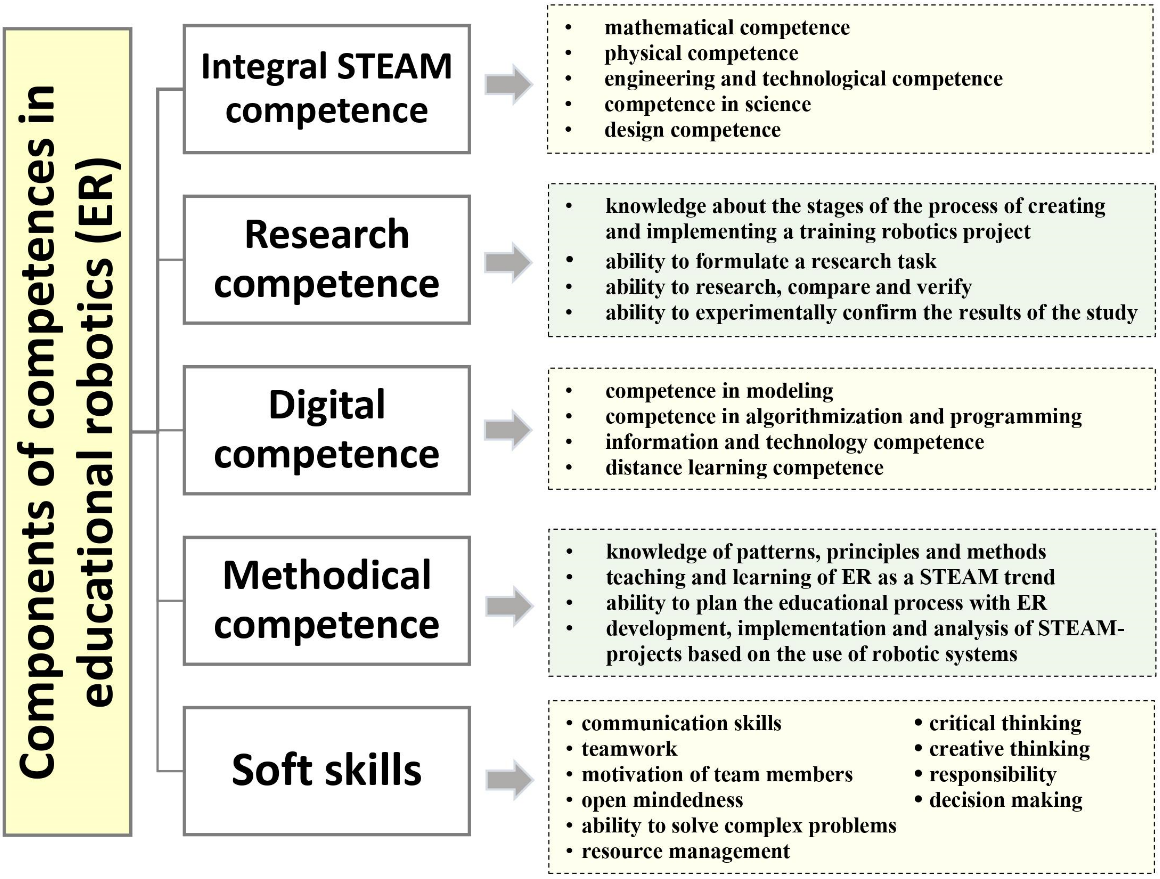

Figure 2: Model of competences in educational robotics for teachers.

part of the training of pre-service teachers (Strutynska, 2019b).

Summarizing the experience of practicing educators who teach educational robotics and research the preparation of pre-service teachers for its teaching, our previous research and experience, the authors believes that in the absence of a separate educational standard in Ukraine “Robotics”, ***pre-service Computer Science teachers*** are the most ready to teach educational robotics in secondary schools.

Strutynska (Strutynska, 2019b) substantiates in detail the feasibility of training pre-service teachers of computer science to teach educational robotics. Similar considerations are also shared by other researchers. For example, Vegner (Vegner, 2013) believes that the most appropriate discipline for the training of specialists in the field of robotics is computer science. In his opinion, it is necessary to start training the future robotics engineer from the school time. However, this problem is rather difficult to solve within the traditional set of physical and mathematical disciplines.

Buzhinskaya and Grebneva (Buzhinskaya and Grebneva, 2018) note that computer science is a leading discipline for teaching educational robotics. It should be taught by computer science teachers, respectively, as part of the school computer science course.

Zhaldak et al. (Zhaldak et al., 2020a,b) developed the educational and professional training programs for bachelors and masters in the specialty 014.09 “Secondary education (Computer Science)” with a selective module of disciplines “Educational robotics” at the Faculty of Informatics of the National Pedagogical Dragomanov University. This is just to train pre-service computer science teachers, who will teach educational robotics. In the absence of a separate educational field “Robotics” according to the state standard of education, pre-service computer science teachers, who have chosen a selective unit of disciplines “Educational Robotics”, receive an additional qualification “head of the robotics club”.

Students of computer science specialties of pedagogical university study disciplines of the selective module "Educational Robotics". These disciplines combine theoretical, applied and practical aspects of STEAM education. The main content lines of educational robotics are:

- *Basics of robotics*
- *Introduction to educational robotics*
- *Programming of robotic systems*
- *Physical basics of robotics*
- *Mathematical basics of robotics*
- *Methods of teaching educational robotics*

The experiment, which was conducted three academic years (2017–2020), involved 106 students who studied in the specialty 014.09 "Secondary education (Computer Science)". During each subsequent academic year, changes were made to the structure and content of training disciplines in educational robotics (ER): 2017–2018 – 28 students (educational robotics training took place according to the content of modules of other disciplines – 16 students of the Bachelor program and 12 students of the Master program); 2018–2019 – 32 students (the training took place both in terms of modules of other disciplines (18 students of the Bachelor program) and in terms of the content of the selective block of disciplines "Educational Robotics" (14 students of the Master program)); 2019–2020 – 46 students (the educational robotics training took place within the framework of majors courses (23 students of the Bachelor program) and according to the content of the selective block of disciplines "Educational Robotics" (23 students of the Master program)). This selection of experimental groups was due to: a small number of students in groups who were trained in the relevant field of study; homogeneity of the conditions of the experiment (availability of hardware for educational robotics, the same number of hours for training relevant courses, and the same type of software and methodical support); and the dynamics of development of relevant technologies in the robotics industry.

Diagnostics of the levels of building of ER competences of pre-service teachers of computer science for each group was carried out in two stages: by assessing the levels of building of certain competence components at the beginning and after the formative stage of the experiment.

At the final stage of the experiment, there was a self-assessment of ER competences developed in the participants of the experiment. Besides that, the expert assessment of robotics projects (including STEAM and online projects) has been performed. It was done also with the participation of lecturers, practicing teachers, and leaders of educational robotics clubs (as experts). In some cases, mutual evaluation took place. Examination and evaluation of projects were carried out on the basis of the criteria developed by the authors of the study for assessing the final tasks and projects, as well as criteria for assessing the levels of competence components building.

The results of the experiment showed that the quality of training and the level of the building ER competence components of pre-service teachers of computer science increased owing to the proposed method (table 1).

2 Thus, according to the results of the experiment, there is an upward trend in development of ER competences of pre-service teachers of computer science, which confirms the effectiveness of teaching students according to the developed individual components of the methodical system. In particular, the number of students with basic, sufficient and high level of general ER competences has increased: with basic – increased by 7.36% (8 students); with sufficient – by 14.34% (15 students); with high – by 8.87% (9 students). At the same time, the number of students with a low level of these competences building decreased by 30.57% (32 students).

The experience of teaching students in the disciplines of the selective unit "Educational Robotics" showed the following. The training not only provides students with relevant knowledge of educational robotics (introduction to robotics, basic robotics models, design and construction programming of robotic platforms, environments for programming of robotic platforms, organization of tests of ready designs of robots (testing of robots, etc.), but also promotes formation in them of corresponding professional competences in educational robotics.

Besides, students have improved such key competencies as follows while studying:

- *Ability to learn (fast learning)*;
- *Civic competence*;
- *Social competence*;
- *Environmental literacy*;
- *Entrepreneurship*.

Areas of formation of competences in educational robotics for pre-service computer science teachers are:

1) formal training (relevant disciplines in educational robotics, provided by the educational program);
2) practical component of training (project activity of students);
3) non-formal learning (attending master classes by practicing teachers, robotics leaders, mentors and

Table 1: Students' percentage who have reached the stated levels of building of the relevant ER competence components.

ER competence components	**Experiment stage**	**Competences' levels**			
		low	**basic**	**sufficient**	**high**
Integral STEAM competence	at the beginning	22.64%	64.15%	11.32%	1.89%
Integral STEAM competence	at the end	8.49%	43.40%	34.91%	13.21%
Research competence	at the beginning	73.58%	23.58%	2.83%	0.00%
Research competence	at the end	35.85%	50.94%	10.38%	2.83%
Digital competence	at the beginning	28.30%	48.11%	21.70%	1.89%
Digital competence	at the end	9.43%	38.68%	33.96%	17.92%
Methodical competence	at the beginning	86.79%	11.32%	1.89%	0.00%
Methodical competence	at the end	16.04%	60.38%	16.04%	7.55%
Soft skills	at the beginning	31.13%	45.28%	15.09%	8.49%
Soft skills	at the end	19.81%	35.85%	29.25%	15.09%
General ER competences	at the beginning	48.49%	38.49%	10.57%	2.45%
General ER competences	at the end	17.92%	45.85%	24.91%	11.32%

trainers, attending seminars, festivals, robotics competitions, self-education using MOOC, thematic groups and social media channels, etc.).

5 CONCLUSIONS

The introduction of educational robotics as a part of STEAM education is a powerful step for development of students' soft skills, training for the implementation of real socially significant projects, formation of practical value of theoretical knowledge, scientific world outlook and successful life in a digital society as a whole.

Based on the analysis of the world trends in the robotics industry and development of robotics as an educational trend, systematic analysis of scientific, methodological and the Internet sources regarding the research problem, generalization of these data, own experience and previous research (2015–2020), the conclusions are drawn about:

- growing demand for robotics specialists;
- increasing the popularity of robotics as an educational trend in Ukraine and around the world;
- urgency of training teachers to make them able to train future professionals in the field of robotics;
- relevance of the introduction of educational robotics in the educational process of higher education institutions as part of the training of pre-service teachers;
- importance of developing of the competences in educational robotics for teachers;
- effectiveness of the developed model of the Competences in educational robotics for teachers.

The practical experience of training pre-service teachers (who will teach of educational robotics) shows that pre-service computer science teachers are the readiest to teach educational robotics in secondary education. The research confirms the effectiveness of training pre-service computer science teachers for teaching educational robotics in secondary education institutions developed by educational and professional programs of the specialty 014.09 "Secondary education (Computer Science)" with a selective module of disciplines "Educational robotics".

Further research of the author will be aimed at identifying ways to develop educational robotics competences under the conditions of blended and distance learning.

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APPENDIX

Table 2: Description of the components of competences in educational robotics (ER) for teachers.

ER competence	ER competence components	Knowledge	Abilities and skills	Personal traits, ways of thinking
Integral STEAM competence (in the field of robotics)	*Mathematical competence*	basic knowledge of fundamental mathematics sections; mathematical tools in the relevant field of knowledge	ability to use mathematical methods in the process of ER problem solving	algorithmic thinking, systematic thinking
Integral STEAM competence (in the field of robotics)	*Physical competence*	knowledge of microelectronics; understanding the principles of operation of simple mechanisms and mechanical transmissions	ability to work safely with electronic circuits, microcontrollers and robotic platforms in accordance with the project	responsible attitude to technology, understanding and compliance with safety measures when working with robotic platforms
Integral STEAM competence (in the field of robotics)	*Engineering and technological competence*	knowledge of the stages of the engineering design process at the level sufficient for the implementation of projects related to robotic systems	ability to design robotic systems	engineering thinking, technological literacy, systematic thinking
Integral STEAM competence (in the field of robotics)	*Competence in science*	basic knowledge of environmental sciences fundamental sections at the level sufficient for the implementation of projects related to robotic systems	ability to use knowledge of environmental sciences (including their interdisciplinary links) within the process of ER problem solving	
Integral STEAM competence (in the field of robotics)	*Design competence*	basic knowledge in the field of design at the level required for the design of robots and their parts	ability to create the design of robots and their parts, including using 3D technology	design thinking
Research competence		knowledge about the stages of the process of creating and implementing a training robotics project	ability to identify the problem; ability to formulate a research task and determine ways to solve it; activity planning; ability to research, compare, verify and experimentally confirm research results; system analysis, system evaluation	engineering thinking, the ability to solve problems in a non-standard way, understanding other points of view in solving problems; ability to apply knowledge in different situations
Digital competence	*Competence in modeling*	knowledge of methods of analysis, research and development of robotic systems models	ability to develop models of robotic systems; ability to adopt ICT for computer modeling of robotic systems	systematic thinking

Continued on next page

Table 2: Description of the components of competences in educational robotics (ER) for teachers (cont.).

ER competence	**ER competence components**	**Knowledge**	**Abilities and skills**	**Personal traits, ways of thinking**
Digital competence	*Competence in algorithmization and programming*	basic knowledge in the field of algorithmization; basic knowledge of one or more programming languages; features of their use for programming robots and robotic systems	ability to develop algorithms of robots and robotic systems, ability to program and test them	algorithmic thinking, systematic thinking
Digital competence	*Information technology competence*	knowledge of the characteristics of robotic platforms and the corresponding software; basic knowledge of the technologies operation principles based on the IoT	ability to select robotic platforms in accordance with the tasks, ability to work with emulators of robotic platforms; ability to use technologies based on the IoT to develop robotic systems	responsible attitude to technology, understanding and compliance with safety measures when working with robotic platforms and IoT
Digital competence	*Distance learning competence*	knowledge about the principles of functioning of online environments for robotics training, distance learning systems, video conferencing systems; knowledge of features (including psychological) concerning the organization of independent work of students in the conditions of distance learning	ability to work with online environments for robotics training; ability to organize the educational process using online environments; ability to design, create digital educational resources (including distance learning courses) with ER	understanding the principles of safe work in online environments; compliance with safety measures when working on the Internet, ethics; independence, motivation; psychological stability to work in distance learning
Methodical competence		knowledge of the principles of cognitive management; understanding the importance of the introduction of ER as a trend of STEAM education for the formation of students' scientific worldview; knowledge of patterns, principles, methods of teaching and learning of ER as a trend of STEAM	ability to plan the educational process with ER; development, implementation and analysis of STEAM projects based on the use of robotic systems; creation of learning environments and conditions for effective learning of ER, evaluation of ER learning outcomes	motivating students to learn ER
Soft skills			Communication and teamwork skills, solve complex problems, ability to make informed decisions, resource management	critical thinking, creative thinking, responsibility, motivation of team members, open mindedness, emotional intelligence

Using Unity to Teach Game Development

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Keywords: Computer Science, Education, Computer Game Development, Unity Engine, Software Engineering.

Abstract: The article gives an overview of issues arising in connection with the organization and conduct of the course "Computer game development" in the master's program 014.09 Secondary education (Informatics). The study of the experience of similar courses in other educational institutions does not give an idea of what conditions are the best for conducting it, because "Computer game development" is mainly present in the curriculum of the Software Engineering specialty and is not limited to one course. The game development course is described in terms of content, software and teaching methods. This course, which was attended by 40 students in three years, was evaluated in the light of the approach proposed by A. D. Ritzhaupt and based on the students' opinion. As a result of this research, it was concluded that a course in video game development could be based on the Unity Engine, as it has a small entry threshold, free for academic purposes, a crossplatform, real game engine, common in the gaming industry. A team strategy for this course is also effective.

1 INTRODUCTION

The software industry is a dynamic and market-oriented industry (Vakaliuk et al., 2020b). Along with the film industry, video games are one of the most interesting and popular applications of information technology (Haranin and Moiseienko, 2018; Katsko and Moiseienko, 2018).

Gamesindustry.biz journalists, along with analysts from Newzoo, UKIE, Sensor Tower, IHS Markit, ICO Partners and Fancensus, published a large infographic on the state of the game industry in 2020 (figure 1). It implies that computer games occupy a significant segment of the software market.

Educational institutions that train software engineers include game development as a set of relevant subjects in the curriculum. The reasons for their inclusion are diverse and include, inter alia, improving the effectiveness of the curricula (Barnes et al., 2007; Claypool and Claypool, 2005; Morrison and Preston, 2009; Roden and LeGrand, 2013; Sung, 2009), increasing the competitiveness of graduates in the modern labour market (Haranin et al., 2017; Vakaliuk et al., 2020a), learning team work (Brown et al., 2009;

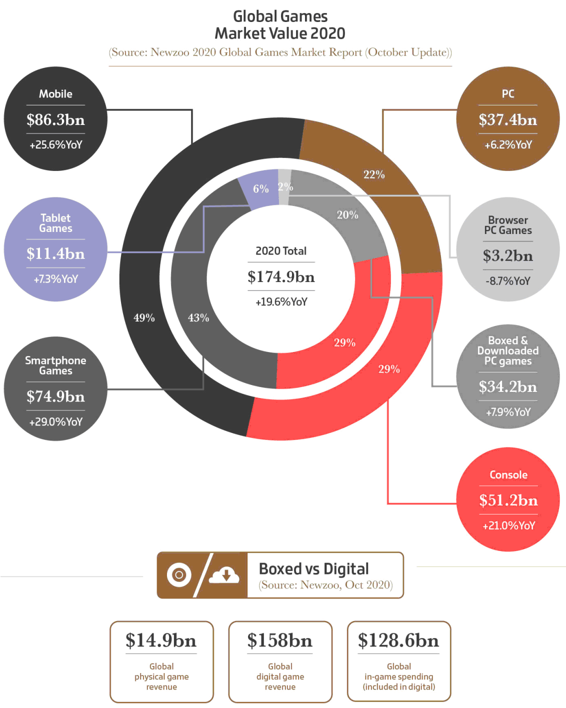

Figure 1: Global Games Market Value 2020 (Batchelor, 2020).

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Rankin et al., 2008) and project management (Barnes et al., 2007; Claypool and Claypool, 2005).

Despite this, many higher education institutions carefully include such courses for a variety of reasons, including the need to create games of some interdisciplinary skills, time constraints, lack of interest and experience among teachers in teaching games or the view that game development is not serious (Becker and Parker, 2007; Martin and Smith, 2002).

As teachers of Computer Science at Pedagogical University, we consider the inclusion of a variation course of computer game development in the curriculum of Masters 014.09 Secondary Education (Informatics) as a way to increase the level of motivation, engagement and professional pleasure for students.

The *purpose* of this article is to give an idea of the creation of a separate game development course, an overview of the methodology and tools used in its construction and the conclusions drawn so that teachers without experience, all of which have set such a course, have been able to avoid unnecessary waste of time. We describe our experience in creating an individual game development course using the Unity Game Engine (Unity Technologies, 2021). The aim of this course is to familiarize students with the development of games using the software available in industry. We focus on problem solving, project planning, SDK work, and teamwork, and see this course as a way to entertain and motivate students.

2 BACKGROUND

The first task of the game development course was to select an approach. Defining the content, goals and objectives of game development is an important step, especially in the light of limited material and time resources.

A review of publications on the subject shows that the implementation of training programmes on game development is quite diverse. It varies from individual courses (Jones, 2000; Parberry et al., 2005; Sweedyk and Keller, 2005) and the inclusion of relevant sections in the traditional computer science program (Coleman et al., 2005) before the course sequence (Clark et al., 2007; Fachada and Códices, 2020; Parberry et al., 2006; Rocco and Yoder, 2007; Prokhorov et al., 2021). Content of individual courses from the use of engines developed for training (Gamemaker (Claypool and Claypool, 2005), RPG Maker (Barnes et al., 2007), Alice (Werner et al., 2012)), development of own game engines (Labyrinth (Distasio and Way, 2007; Shultz, 2004), CAGE (Vanhatupa, 2011)), technical design (Parberry et al., 2006), Flash (Estey et al., 2010) to a complete game development training course covering all aspects of the game (Jones, 2000; Martin and Smith, 2002).

The idea of developing a proprietary engine seems tempting at first, but, in experience, does not pay for itself by the time it takes, and eventually students will never see it again after the course (Dickson, 2015). The real game engine should simplify and speed up the development process and allow students to create interesting games in a short period of time. The problem of finding the most suitable game engine for this course is not very simple, and there are different opinions on this issue from the XNA Game Studio library to Unity and Unreal (Dickson, 2015; Dickson et al., 2017; Unreal Engine, 2021; Harris, 2011; Linhoff and Settle, 2008; Parberry et al., 2005; Peng, 2015). Dickson (Dickson, 2015) offers to use the Unity game engine (Unity Technologies, 2021) to teach game development. Given its widespread use in the industry (de Macedo and Rodrigues, 2011; Toftedahl and Engström, 2019) and even for teaching game development in the middle school (Comber et al., 2019), this seems logical.

There are also several important CS sections directly used in the development of computer games: the basics of physics, multimedia, network basics, computer graphics, and the basics of game artificial intelligence (Ahlquist and Novak, 2007; Millington, 2019; Yannakakis and Togelius, 2018).

Game design usually refers to the design of the game and focuses on story, mechanics, character modelling, environment, process content generation, etc., which is enough material to take a whole semester without going into too much detail. There are many textbooks covering these broad topics, such as (Adams, 2013; Ahlquist and Novak, 2007; Saulter, 2007; Bond, 2014). These areas are compulsory for the course.

3 SELECTING THE SOFTWARE

Once the approach to the gaming course was defined, the next question we faced was what tools to use to create games.

More recently, developers have made widely available many powerful game engines and development environments that provide functionality for video game development. An overview of some of the best known is presented below.

Godot Engine (Bradfield, 2018; Manzur and Marques, 2018)

Cost and Licensing: Completely free and open source under the permissive MIT license.

System Requirements (minimum): Memory: 4 GB, Graphics Card: NVIDIA GeForce 6200, CPU: Intel Core 2 Duo E8400, OS: Windows 7.

Platforms: Linux, Windows, OS X, Wii, Nintendo 3DS, PlayStation 3, PS Vita, Android, iOS, BBX, web-games with asm.js, NativeClient.

Overview and Features: Godot Engine is a feature-packed, cross-platform game engine to create 2D and 3D games from a unified interface. It provides a comprehensive set of common tools, so users can focus on making games without having to reinvent the wheel. Games can be exported in one click to a number of platforms, including the major desktop platforms (Linux, macOS, Windows) as well as mobile (Android, iOS) and web-based (HTML5) platforms.

Unity Engine (Unity Technologies, 2021)

Cost and Licensing: Personal Free version (your project revenue or funding cannot exceed $100,000 a year), Unity Pro package $125 per month (includes an impressive amount of services not included in the free version).

System Requirements (minimum): Graphics Card: DX10, DX11, and DX12-capable GPUs, CPU: X64 architecture with SSE2 instruction set support, Windows 7 (SP1+) and Windows 10, 64-bit versions only.

Platforms: Android, iOS, Windows Phone 8, BlackBerry, PS3, Xbox360, Wii U and web-browsers.

Overview: Unity is a cross-platform game engine. The engine can be used to create 2D/3D, virtual reality, and augmented reality games, as well as simulations and other experiences (Axon, 2016; Takahashi, 2018). The engine has been adopted by industries outside video gaming, such as film, automotive, architecture, engineering and construction.

Features: Creating and Destroying GameObjects, Access the Components, Events for GameObject, Dealing with Vector Variables and Timing Variables, Physics Oriented Events, Coroutine and Return Types.

Unreal Engin (Unreal Engine, 2021)

Cost and Licensing: Free (5% royalty on gross revenue more than $1,000,000).

System Requirements (minimum): CPU: Quad-core Intel or AMD processor, 2.5 GHz or faster, Graphics Card: NVIDIA GeForce 470 GTX or AMD Radeon 6870 HD series card or higher, RAM: 8 GB Windows 7 64-bit or Mac OS X 10.9.2 or later.

Platforms: iOS, Android, Windows Phone 8, Xbox360, PS 3, PlayStation Vita, Wii U.

Overview and Features: Unreal Engine is a complete suite of development tools for anyone working with real-time technology. From design visualizations and cinematic experiences to high-quality games across PC, console, mobile, VR, and AR, Unreal Engine gives you everything you need to start, ship, grow, and stand out from the crowd.

XNA Game Studio (Harris, 2011; Linhoff and Settle, 2008; Miles, 2011)

Cost and Licensing: Free download from Microsoft site.

System Requirements (minimum): Graphics Card Shader Model 1.1 support, DirectX 9.0 support, Operating System: Windows Vista SP2, Windows 7 (All editions except Starter).

Platforms: Windows, Xbox 360, Zune.

Overview and Features: XNA Game Studio 2.0 – application framework, integrated development environment. Features: Game component models, New framework library designed to support Microsoft Windows, XBOX 360, and Zune game development, Integration with XNA Framework Content Pipeline.

From an analysis of the capabilities of the video game development tools described, it can be concluded that they are all quite powerful. The choice of a specific tool is determined by the characteristics of the project being developed. Their use for educational purposes is almost equal, although the choice may be influenced by the size of the proposed course.

The second parameter to choose the instrument was its cost. All the tools described are free of charge for educational purposes and thus meet our needs.

The third, perhaps most essential, requirement is compliance with the minimum system requirements of the equipment and associated software. State educational institutions are at a disadvantage in this respect. Therefore, for the first version of the course “Computer game development” in our university was chosen Microsoft XNA Game Studio, which has a narrower range of possibilities.

We assumed that the experience of our students in C/C++ and C# programming would allow them to easily learn XNA. However, we were wrong. By the end of the course, many of them were halfway to the games. The greatest success was achieved by the group of students who developed the Tower Defence class game, but it was completed as part of the bachelor’s qualification work.

The problem with this approach is that in order for students to feel the process of developing games, they need an environment that they can easily use to create games. The focus of the course was to make the game good, not just work at all. We wanted our students to have experience working with a real engine, real skills if they decided to develop games.

The situation improved after the computers at our university were upgraded. We were able to work with a serious game engine. We decided to use the Unity

Table 1: Course part 1. Basics of work in Unity.

Topics	Duration, hours	Course materials	Deliverables
1. Introduction to Unity	3	Unity features. Examples of games created on Unity. Unity installation. The difference between 2d and 3d design. Overview of the main elements of the scene: Camera, GameObject, Direction Light. Moving the scene. Camera object. Location of objects on a 3d scene.	Laboratory work 1
2. Textures, materials and elements of the scene	3	Adding new textures to the project. Creation and use of materials. Shaders and their use. Work with aggregated characters and their components. Creating a Terrain. Terrain Landscape Editor. Trees, grass and surroundings. Placement of a player on Terrain.	Laboratory work 2
3. Scripts and object movement	3	Install Visual Studio Plug-in for Unity3d. Creating scripts. Apply a script to an object on the stage. The structure of the automatically generated script. Creating a character movement using a script.	Laboratory work 3
4. Player management	3	Using the Asset store. Download unitypackage. Use ready-made unitypackage. Creating unitypackage. The structure of projects created by other developers. Use of ready-made asset. Character Controller and its application. Move the object with the keyboard. Dynamic object creation.	Laboratory work 4
5. User interface	3	User interface and its application. Examples of basic controls. Bindings and orientation of controls relative to the working area of the screen. Creating elementary events. Customize Canvas to different screen resolution properties	Laboratory work 5
6. Animation	3	Using ready-made character animations. Create your own animation. Editing curves. Structure and main properties of the Animation component. Animator component	Laboratory work 6

Table 2: Course part 2. Game development based on Unity.

Topics	Duration, hours	Course materials	Deliverables
1. Game Development Basics	1	Game development life-cycle. Game terminology. Overview of game industry	Game Concept plan
2. Creating a character	3	Uploading models to the project. Features of creating game characters. Customize avatars for models that use humanoid animations. Working with the Animator component. Animator controller settings. Retargeting of humanoid animated clips.	Characters modelling and animation
3. Finding a way	3	Creating a game scene. Navigation grid settings. Add and adjust obstacles. Implementation of the movement of the character on the navigation grid.	Group projects element
4. Inverse kinematics	5	Animation settings. Attaching skeletal parts to objects. Creating a script to work with inverse kinematics. Fixation of skeleton points. LineRender component.	Group projects element
5. Characters not controlled by the player	6	Creating a slider and stylizing it. Move the coordinates of the slider to the position above the target. Creating goal health scripts. Using Raycast.	Group projects element
6. Construction of game levels	12	Creating a game level. Overlay post effects on the main camera. Set up bots to search for enemies. Game level layout. Creating multiple teams. Configuration and error correction. Possibility of application of scattering of bullets at shooting.	Final Game

Engine because it has a less steep learning curve than Unreal. It can be used to develop games for any platform, including the Web, for real games, not just training games for learning. Unity scripting can be done in C# or JavaScript, with which our students have already had experience.

Table 3: Useful course element percentages, mean, and standard deviation.

Useful elements	**1**	**2**	**3**	**4**	**5**	**M**	**SD**
The way in which the material was approached	0	5	40	32,5	22,5	3,73	0,88
The pace at which we worked	2,5	10	45	30	12,5	3,4	0,93
Working with peers inside and outside of class	0	7,5	22,5	42,5	27,5	3,9	0,9
Viber discussion group	2,5	7,5	32,5	40	17,5	3,63	0,95
Teamwork in labs	0	2,5	15	57,5	25	4,05	0,71
The presentation of the final group project	0	10	20	45	25	3,85	0,92
The hands-on labs activities	0	5	25	32,5	37,5	4,03	0,92

Table 4: Student learning gains percentages, and mean.

Student gains from course	**1**	**2**	**3**	**4**	**5**	**M**	**SD**
Understanding the main concepts in game development	0	5	25	42,5	27,5	3,93	0,86
Understanding the game development process	2,5	2,5	10	60	25	4,03	0,83
Understanding Unity Engine using in game development	0	5	15	37,5	42,5	4,18	0,87
Ability to think through a problems in game development	0	1	10	20	9	3,93	0,76
Confidence in your ability to work in game development	0	5	25	47,5	22,5	3,88	0,82
Feeling comfortable with complex game development	0	2,5	35	45	17,5	3,78	0,77

4 ORGANIZATION OF THE COURSE

We wanted to build the course in such a way that students could learn the basics of Unity quickly enough and focus on creating the game for most of the semester.

After studying Paul E. Dickson's works (Dickson, 2015; Dickson et al., 2017), our first thought was to build a course based on a book with examples that could guide both us and our students, for example, Unity 3.x Game Development Essentials (Goldstone, 2009). One game is built throughout the book, each chapter introduces a new concept and aspect of the game. All examples of code are written in JavaScript and C#. This book quickly gives an idea of colliders, particle systems, etc. for anyone with no experience in game development. The work on the book provides enough information to study the basics of Unity.

One of the problems is the rapid development of Unity and the need to find relevant materials for work. Unity has an active online community that helps to find textbooks to cope with the new features and changes in Unity and could base the course on one of the online textbook series. However, since the duration of the course was only one semester, it was necessary to develop a manual sufficient to carry out the laboratory tasks in order to use the books only as an additional source of information.

Our goal in this course is to give students a sense of the game development process with a focus on project management, teamwork, and problem solving. The first part of the course focuses on teaching students to use Unity, and the second part focuses on developing real play by groups of students. Classes were held for 3 hours per week: 1 hour of lectures and 2 hours of laboratory work. The basic structure of the course is shown in table 1, 2.

The method that we used in the first part of the course, to organize the study of Unity students, was to combine work on the assignments in the classroom with the performance of additional creative tasks by ourselves. In each work, students had to understand in detail what had been done in the classroom in order to determine how to complete the extra assignment. During the first part of the semester, students sought to learn how to solve various problems with Unity before they began working on their final game projects that required these skills. During this work, students built a basic game in which the player could control the movement and actions of the character in their environment.

5 RESULTS

It's hard to measure success when students are building different games. By calling the game playable, we mean that the students have created a mechanic for the game (possibly with minor errors), combined the art assets with the mechanics and made some introduction (history, list of game items) that enters into the game. In order to evaluate the results of our course "Computer game development" we used some parameters offered by Ritzhaupt (Ritzhaupt, 2009) to evaluate its such course.

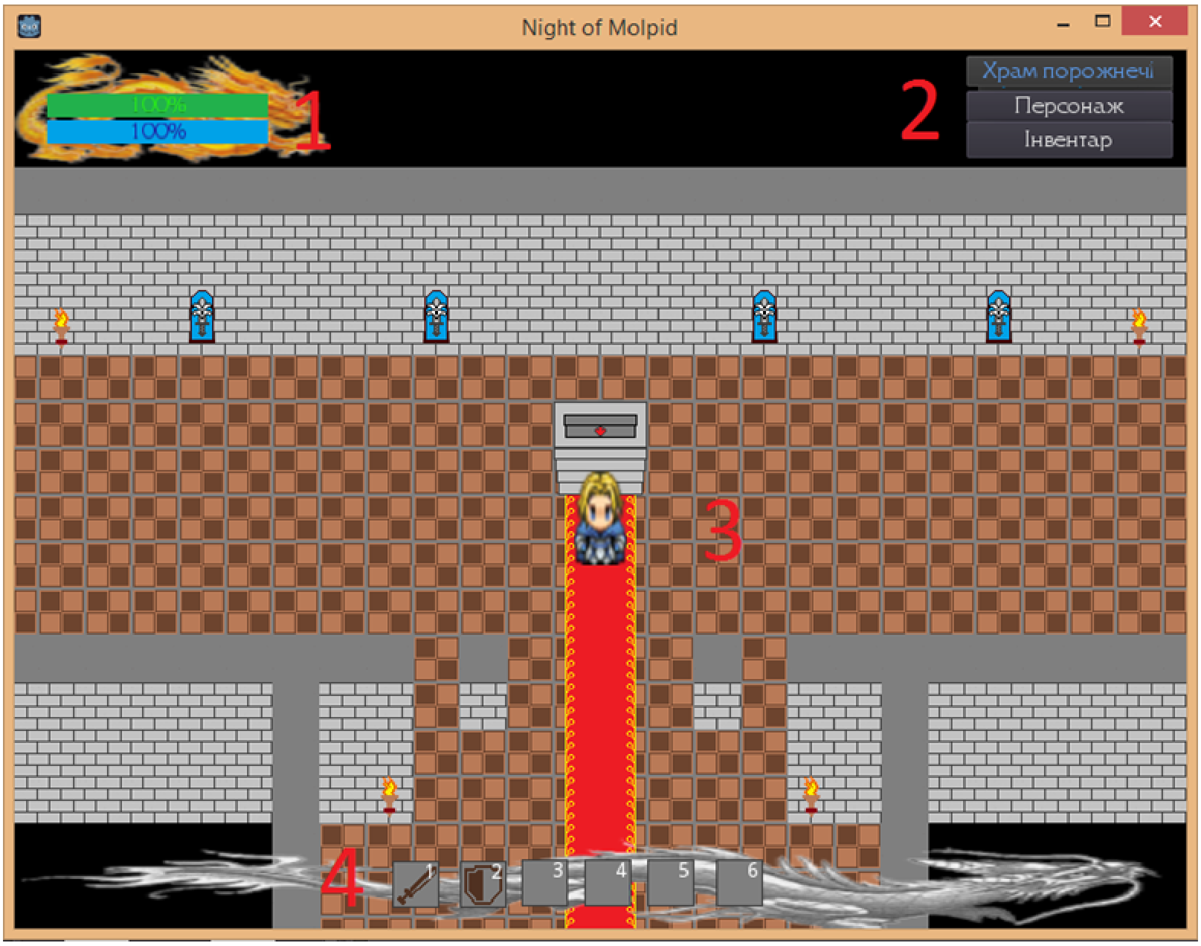

Figure 2: RPG game.

Figure 3: Quest game.

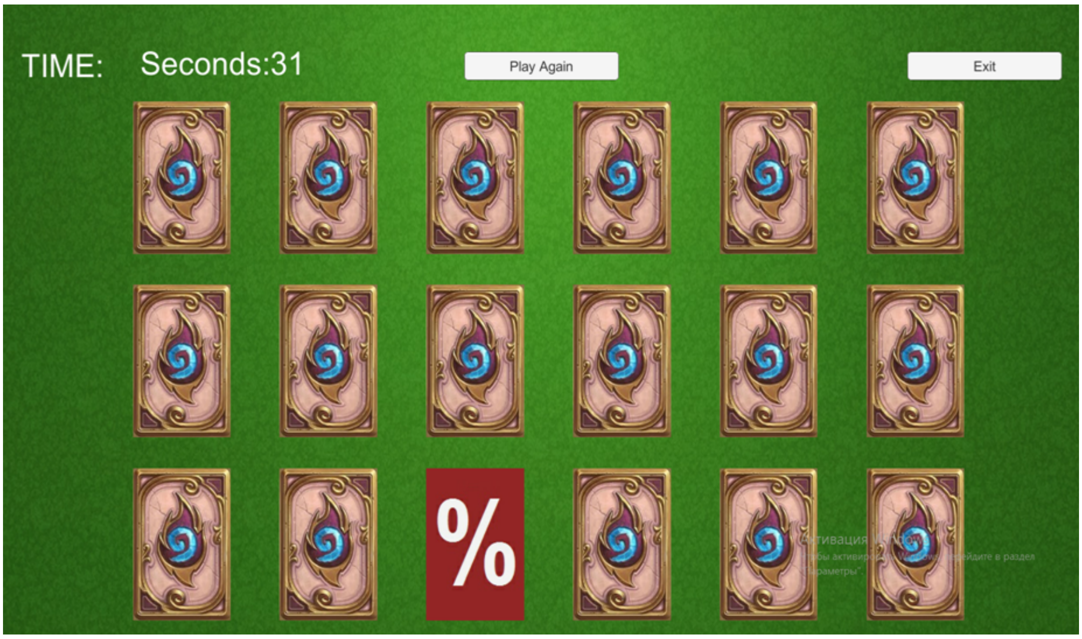

Figure 4: Logical game.

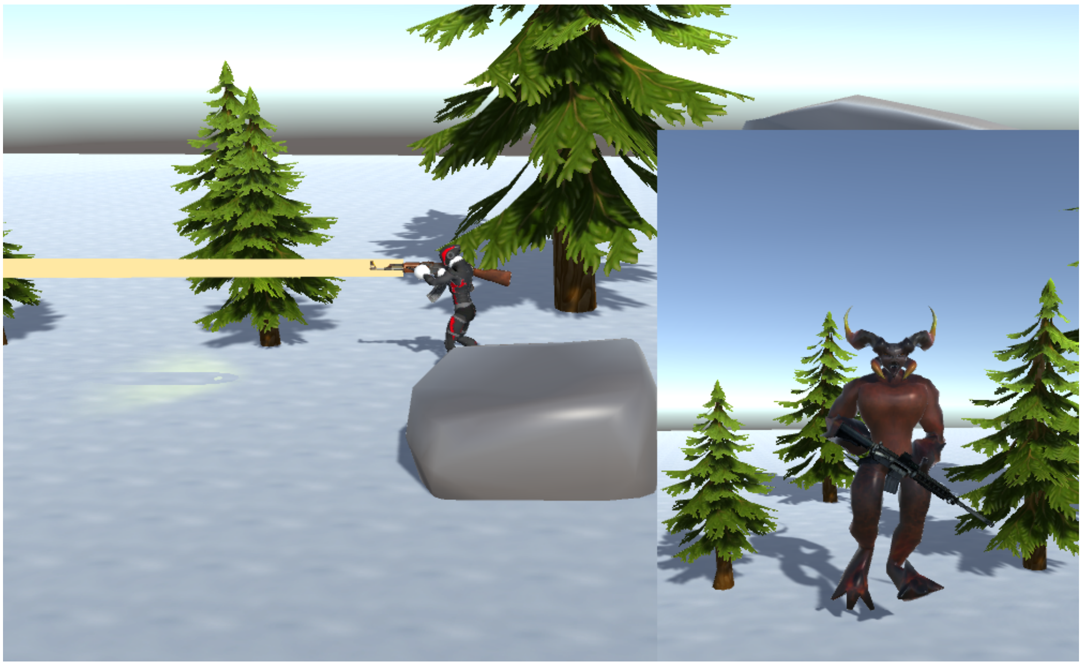

Figure 5: Action game.

5.1 Usefulness of Course Elements for Students

For studying the elements of the course that proved successful, we asked the students to indicate which elements of the course were useful for learning in the range from 1 – “not useful” to 5 – “very useful” (table 3). Of particular interest are the highly rated elements: teamwork in labs ($M = 4.05$; $SD = 0.71$), working with peers inside and outside of class ($M = 3.9$; $SD = 0.9$), and the hands-on labs activities ($M = 4.03$; $SD = 0.92$). These results underline the importance of sufficient work in the computer laboratory and cooperative training in the game development course.

5.2 Student Assessment of Gains

Students were asked to evaluate their post-graduate achievements in a number of areas related to the development of games on a scale of 1 to 5 (table 4). The results showed that they made the most progress in understanding the game's development ($M = 4.03$; $SD = 0.83$) and the ability to use the Unity Engine ($M = 4.18$; $SD = 0.87$). In all other areas, progress has also been above average.

5.3 Final Project Game

In the second part of the course, students worked in groups (3–4) to create final game projects. We allow students to decide for themselves which games they want to develop and how to split into groups. Each group decided who would play what roles and what they would need to do to finish the game. Lectures on this part of the course covered a wide range of topics. Some specific aspects of game development that students are likely to need were discussed. All practical tasks for this part of the course are related to keeping students on their way to finishing the final project games. These include students presenting game ideas, project plans, vertical slices, usability tests, a final game, and weekly reports on who has achieved what.

Most of the groups were able to successfully build a playable game for the final project, which is significantly better than the previous version of the course. Students created RPG games (figure 2), quest games (figure 3), logical games (figure 4) and action games (figure 5). The variety of these games shows that students are free to create games of their choice instead of being limited to the genre and content given by the teacher.

6 CONCLUSIONS

This version of the course made more progress than the one based on the XNA Game Studio, even though students had to learn to use Unity in a short time. The fact that the game engine incorporates everything necessary to connect the player, the art and the surroundings greatly influenced what students could achieve.

Although, in order to keep up-to-date with video game development, it makes sense to focus on game development rather than learning the tool, implementation in the form of a set of courses.

The video game development course can be based on the Unity game engine, as it has a small entry threshold, free of charge for academic purposes, a cross-platform, real game engine common in the game development industry. Based on our experience, Unity is a good option to teach a separate game development course. Since Unity is easy to learn, students can get it in less than half a semester, which leaves more than half a semester to focus on any topic you consider important (game design, project management, etc.).

Another result of this analysis is the effectiveness of cooperative learning and teamwork strategies, especially in computer laboratories.

One of the most important conclusions we have reached is that learning to design games requires a change of perspective from the teacher-centred environment in which the teacher dictates the learner's learning experience (e.g., leadership from outside (King, 1993)). A learning environment in which students have greater control over what they learn and teachers serve as facilitators in this process.

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Expanding Opportunities for Professional Development through the Use of Integrated Teaching

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Abstract: The article highlights the problem of introducing integrated teaching the students majoring in economics in the educational process of Ukrainian tertiary non-linguistic schools. It presents the peculiarities of the immersion into a foreign language environment arising from the acquisition of the professional knowledge in a foreign language. Some strategies for integrated teaching are suggested: 1) systematic repetition of the linguistic and professional material; 2) use of each language unit, which is under study, in its maximum possible linguistic and professional environments and in the connection with the previously learned material; 3) implementation of a major subject (Microeconomics) and a foreign language (English) integration in the educational process of Ukrainian tertiary schools. The programme duration was 4 months. A total of 90 students majoring in economics participated in the programme of integrated teaching. After the completion of the programme the students' professional knowledge and foreign language proficiency were assessed and their feedback collected and analyzed. Data were obtained from pre-and-post assessment tests of language and professional proficiency. Results indicated the effectiveness of the suggested educational strategies, the use of which provided a possibility of the transition from training period to a real professional communication.

1 INTRODUCTION

The current stage of the society development is characterized by a rapid flow of information in many previously existing areas of knowledge, as well as in the "newly-born" scientific fields. Providing students with knowledge of new discoveries in these fields of science, technology and production, without violating young people's interests in studying the fundamental laws of nature, society and humanity development, which were included in the curricula of the past, can't be implemented because of the impossibility of academic hours increase at universities.

Therefore, the way to resolve the contradiction between the constantly-increasing flows of information and the lack of time for its mastering, the scholars see in the process of merging adjacent areas of knowledge into one subject integrity. It will allow students achieving the highest level of skills development in two activities: a professional activity and a foreign language speech activity. Moreover, this idea is being deepened and updated nowadays due to the growing need in highly-qualified specialists who should be able to implement their professional skills in a foreign language.

The choice of this direction of study is based on the Conceptual Principles of State Policy for the English language development in Ukrainian higher education establishments from 13.07.2019 which emphasize the importance of English for enhancing people's educational and professional opportunities

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Expanding Opportunities for Professional Development through the Use of Integrated Teaching.
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(mon.gov.ua, 2019). In our opinion, such an organization of professional training in English should contain an invariant component in order to take into account the following: the content of the professional discipline; the level of professional knowledge of this discipline and the proficiency in English as a means of teaching it; definite methodological actions of integrated teaching two disciplines; the previous foreign-language linguistic experience of learners.

There are many research works examining the specifics of integrated teaching implementation at education systems in different countries: Poland (Czura et al., 2009; Leshchenko et al., 2018; Papaja, 2013), Germany (Dallinger et al., 2018; Hallet, 2015), Denmark (van Kampen et al., 2020); Spain (Ardeo, 2019; Marsh, 2013; Merino and Lasagabaster, 2018); Latin America (McDougald, 2016); North America (Maguire-Fong and Mangione, 2016); India (Doraisamy and Radhakrishnan, 2013); Kazakhstan (Dontsov and Burdina, 2018); China (Xiao, 2016). But despite the fact that all education systems have their own specific features of integrated teaching implementation, all scholars stress that such integrated technique works successfully in every educational environment.

It should be stressed that nowadays in the world there are more and more English undergraduate programmes for the students who would like to increase their competency in a foreign language and a major subject offered by European Universities. These programmes turned out to be not only popular but became a strategic means of education internationalizing.

The research "English-language Bachelor's programmes: internationalization of European higher education" conducted by the European Association for International Education (EAIE) and the Study Portals (Sandstrom, 2018) in 2017 showed that 33% out of 2317 respondents indicated education in a foreign language as a priority area of internationalization of University educational programmes. However, the number of English-language undergraduate programmes varies greatly across countries. EAIE has studied 19 European countries and analyzed: the number of English-taught bachelor's programmes (ETB); the number and percentage of higher educational institutions (HEIs) offering ETBs in each country to see if the programmes were limited to a few institutions or were more widespread; share of HEIs offering ETBs. According to the obtained data, the leading countries which have English-language undergraduate programmes are the following: Turkey (545 programmes), the Netherlands (317), Denmark (159), Switzerland (134), Poland (131), France (95). The smallest number of English-language undergraduate programmes is in Romania (32).

Among the most common areas where the education is taught in English are the following: business, management, social sciences and engineering. If to compare the quantity of the countries which offer professional programmes in English, then the leaders are the following countries: the Netherlands (42), France (41), Poland (40), Switzerland (35), Turkey (32), Denmark (23). The smallest number of universities is again in Romania (8). A different picture emerges when we assess the relative share of universities offering English-language education. In Switzerland almost all universities offer programmes in English, so this country can be called the place with a maximum degree of penetration of English-language education. Then Turkey has 94%, the Netherlands and Denmark follow having 75% and 70% of such universities respectively. The lowest percentage of universities offering professional education in English is in Poland (14%), France (13%), Romania (9%).

Thus, from figure 1 it is seen that in spite of different number of universities offering ETB and the English-taught bachelor's programmes in the abovementioned countries, integrated teaching is rather popular in European higher education institutions. And the students willingly enrol into them preferring to study not only in the economically stabilized countries such as: Switzerland, the Netherlands, Denmark but also in the countries with low income, for example, Romania or in the economically unstabilized countries, for example, Turkey, only to have a chance to master their profession in a foreign language and to have more chances to integrate into the world community.

Concerning such well-developed European country as Germany, the first programmes of integrated teaching in English appeared in 1990s through the dominance of the English language in international communication. Germany has adopted the subject centred curriculum approach with emphasis on learner-centred tasks in instruction. In the subject-centred curriculum, courses are divided as separate subjects or disciplines but interdisciplinary approaches are also enabled. Nowadays integrated teaching in English is being implemented in many secondary schools in Germany, and a growing number of studies seem to confirm it as a valuable addition to more traditional programmes of language teaching.

The course is intended as an introduction to this field of teaching certain school subjects (providing examples from a range of subjects, e.g. geography, history, politics and biology) through the medium of English. It is estimated that 20000 secondary school

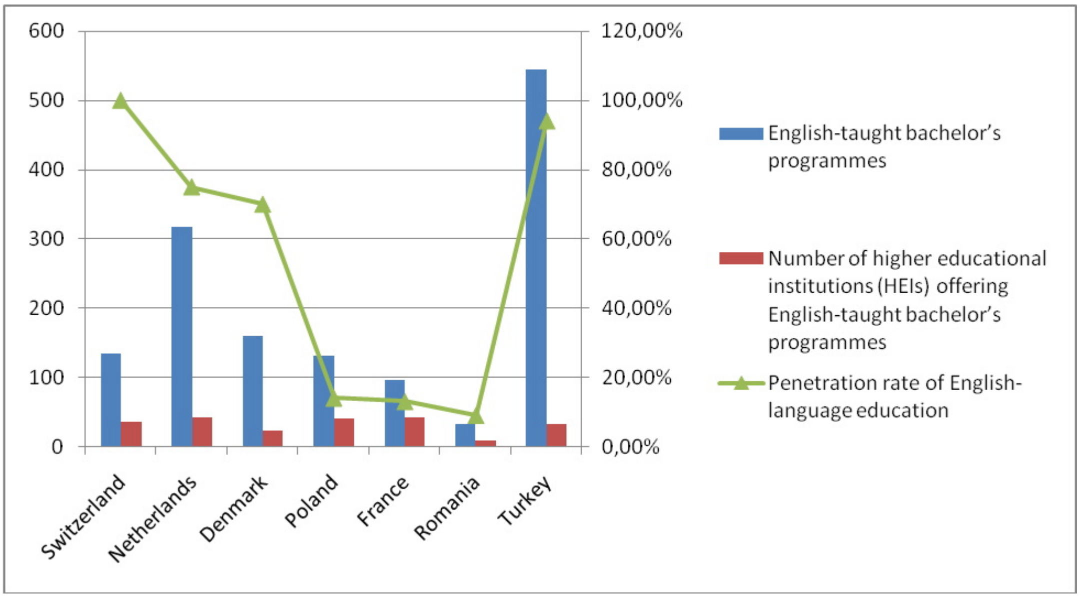

Figure 1: Integrated teaching penetration into European higher education.

students study content subjects in a foreign language. But such great introduction of integrated teaching can be found only in secondary schools (Grenfell, 2002). Speaking about universities, we can say that there are currently only a limited number of undergraduate English-language programs at top universities in Germany. Due to the scarce nature of these programs, if a student really wants to study at a leading university, he may have to be a little bit flexible on his choice of program.

According to the data of QS World University Ranking 2020 (www.topuniversities.com, 2021), there are only 9 leading universities in Germany which offer a bachelor-level degree program taught in English allowing international students to study for a Bachelor of Arts (BA) or a Bachelor of Science (BSc), depending on their major, among them there are such universities as: Universität Freiburg, Frankfurt School of Finance and Management, Karlsruhe Institute of Technology, Georg-August-Universität Göttingen which have a strong international reputation.

So, we can indicate that the decisions in educational policy always have their own effect in different countries. That's why the content and language integration is applied in different countries in different ways. There is no model for export. Despite a great popularity of integrated teaching in the world, Ukrainian Universities don't participate in the international competition offering ETBs to students and still have curricula where major subjects and a foreign language are taught according to different syllabi, not having interdisciplinary connections. Regretfully, there is a small number of tertiary schools in Ukraine, which not only suggest integrated learning but also implement it into practice. To our mind, such situation occurs in tertiary schools in Ukraine due to the following points: lack of teachers who are literate in three domains: a major subject, a foreign language and a teaching integrated strategy that confirms the idea of He and Lin (He and Lin, 2018) stating that for content and language integrated teaching a special kind of teacher with integrated content knowledge and knowledge about language should work (He and Lin, 2018); absence of subject textbooks in a foreign language adapted for non-native speakers and pedagogical guidelines how to teach parallel non-linguistic and linguistic disciplines; students' insufficiency of the prior linguistic experience. Smit and Dafouz (Smit and Dafouz, 2012) state that process of integrated learning / teaching will become better in the future, as a new generation of students and teachers mastering in foreign languages appears in higher education.

The tendency of different subjects integration into one unity has already been under consideration of Ukrainian scholars. There are research works examining the content and language integrated teaching for future: ecologists (Kordonova, 2014), psychologists (Petrova et al., 2020), engineers (Popel, 2015), technical students (Martín del Pozo, 2015), economists (Kostetska et al., 2020; Luchaninova et al., 2019), medical students (Bhardwaj et al., 2015), mathematicians (Martínez and Dominguez, 2018; Lazorenko, 2016), physicians (Merzlykin et al., 2018), seafarers (Litvinenko, 2015; Primina, 2017) etc. However, in all these works the accent was done mainly on some English teaching points: how to make presentations of technical equipment; how to make oral professionally-oriented speech; how to read drug prescriptions or sailing directions. It did not solve the existing contradiction between the needs of the University graduates to use English to acquire new knowledge in the professional sphere and communicate in fluent English beyond the environment of integrated learning and their real language proficiency.

We consider that the achievement of such task will be mostly facilitated by the procedural integration of professional and foreign language activities. According to Tarnopolsky (Tarnopolsky, 2018), integration is a process that ensures parallel acquisition of knowledge from certain non-linguistic disciplines together with the acquisition of the target language and the skills of communicating in it. Integrated teaching is defined by Snow et al. (Snow et al., 1989) as training in which the emphasis shifts from isolated language teaching for professional communication, to association, integration, language acquision with the study of special disciplines (Spanos, 1989). As for procedural integration, we, following the ideas of Martynova (Martynova, 2016) and Nenkov et al. (Nenkov et al., 2017), regard it as the synthesis of teaching processes of different subjects, the contents of which are not merged into a single unity, but must be learned during one educational process at the same period of time and with the pedagogical efforts of the same teachers. Its dual-focused character is considered to be a challenge both for teachers and students as it represents a combination of learning a major subject context and a foreign language.

However, you should keep in mind that one of the subjects under study should not have its own semantic content in order not to conflict with the subject that carries the main semantic load. It needs mentioning that any professional subject and a foreign language can form a methodical symbiosis. And as a result of this symbiosis, a natural foreign language environment arises. The major subject is taught in a foreign language.

All elements of the teaching process, namely: the introduction of a new material, the interpretation of new concepts, the perception of the lecture topic and its note-taking, the key points understanding, implementation of practical actions based on the perceived and comprehended lecture information, revision of the lecture content, performance of creative tasks on the basis of the acquired knowledge are carried out in a foreign language.

Thus, in the procedural integration, a foreign language environment is created not for performing individual educational activities, but for acquiring educational and professional knowledge and developing on its basis the corresponding skills by means of a foreign language. Therefore, we consider it advisable to analyse this aspect in detail.

The *aim* is to define and characterise the strategies of integrated teaching a major subject and a foreign language to students majoring in economics at Ukrainian tertiary non-linguistic schools. The tasks are:

1) to study the existing ways of integrated teaching and determine their advantages and disadvantages;
2) to offer the methodological strategies for integrated teaching a major subject and a foreign language to students majoring in economics;
3) to determine the integrated teaching stages;
4) to evaluate the effect of integrated teaching a major subject and a foreign language on the education outcome achieved by students.

2 METHODS

The research involved the following scientific methods: the comparison and system analysis of psychological, pedagogical, methodological sources, education process monitoring, pilot integrated training students majoring in economics at Ukrainian tertiary non-linguistic schools, work with the author‘s course for economists “Global economic problems of today and ways to solve them” (Baklanova et al., 2020), describing the experimental stages, processing the experimental data obtained, students’ questioning. Thus, the relevance of the study is based on the needs to train future economists, capable to communicate fluently in English on the professional topics.

2.1 Participants

Following the author‘s integrated course for economists “Global economic problems of today and ways to solve them”, the students have got an opportunity to create a stable basic professional vocabulary to be able to use each language unit, which is under study, in its maximum possible linguistic and thematic environments; to develop foreign language communicative and professional skills.

In order to prove the efficiency of the offered integrated course we chose 2-nd-year students majoring in finance who studied at Odesa Trade and Economics institute of Kyiv National University of Trade and Economics and Odesa National Economic University. Before the experimental teaching the students were given the language tests to define their level of knowledge in English. The students, who were chosen for participating in the experiment, had the initial levels of the English knowledge proficiency B1-B2 according to CEFR (Council of Europe, 2001). A total of 90 students participated in the programme of integrated teaching.

The course lasted 1 semester (2018–2019) and had 56 hours of in-class activities along with 50 hours of out-of-class work. The classes were held 2 times a week. The work was conducted at the major subject classes according to the syllabus. But the teaching was done in the English language. As it is still an experimental research, it means that no extra time was added to the educational process. Thus, our intention was to save time for learning two disciplines simultaneously and to connect these disciplines reducing the gap between the professional subject and a foreign language which are usually taught separately in the Ukrainian Universities therefore the students are not always able to combine these two pieces of knowledge into one unity.

With the purpose of comparing the efficiency of different ways of teaching the professional English language all students were divided into two groups: experimental (our teaching strategies) and control (here the students learned their major subject in the native language and had English classes studying by course book "English for Economists" by Aghabekyan and Kovalenko (Aghabekyan and Kovalenko, 2004)). The difference in their studying was in the content and character of educational activities, educational texts and the balance of different kinds of work at the lesson.

At the beginning of the research work a structured questionnaire was used as an instrument for data collection. The purpose was to find out the students' attitude to the integrated teaching course. 90 students of the 2-nd course were questioned.

There were 6 questions which included such items:

1. How do you understand the word "integration"?
2. Do you know what an integrated teaching means?
3. What subjects can be integrated?
4. Have you already had any experience of integrated teaching at university?
5. Would you like to attend integrated classes?
6. Is it important to have a good command of English to attend integrated classes?

On the basis of the questionnaire the following answers were obtained. As for the first question practically the students gave a bit different but correct answers how they understood the word "integration" in general. For example, "Integration is the act of bringing together smaller components into a single system that functions as one unity" (40%), "Integration is a process of combining or coordinating separate elements so as to provide a harmonious, interrelated whole" (30%), "Integration is the action or process of combining two or more things in an effective way" (15%), "Integration occurs when separate people or things are brought together" (10%). And 5% of respondents didn't answer at all.

The second question about "integrated teaching" was understood by 70% of students and 30% were not sure that they were aware of this term. Some students referred to a way of connecting skills and knowledge from multiple sources and experiences (30%), The other part of students said that it meant applying skills and practice from different subjects (25%). The following respondents answered that it simply meant bridging connection between academic knowledge and practical work (10%). The smallest number of students pointed out that it was defined as the organization of teaching matter to interrelate the subjects which are frequently taught in separate academic courses or departments (5%).

Answering the third question the students mentioned different subjects, among them there were some foreign languages, for example, English and German or English and Spain (50%), music and literature (20%), music and fine arts (15%), literature and culture (10%), physics and astronomy (5%). Answering the fourth question all the students declared that they did not have such experience at University. But 5% of students mentioned that they had such an experience at school.

The fifth question confirmed the wish of the students to attend the integrated classes: 90% said that they would willingly attend such classes, 10% were indifferent. And the sixth question showed that all the respondents (100%) understood the importance of knowledge of a foreign language to attend integrated classes especially if the lectures are given in English.

Thus, on the basis of the questionnaire the conclusion about the students' aspiration to have an integrated course of teaching at their University was drawn that proved the necessity of introducing the integrated teaching into the educational process.

2.2 Apparatus and Materials

The research was based on the author's integrated course "Global economic problems of today and ways to solve them" designed for the 2-nd-year students. The theoretical major discipline "Microeconomics" was the basis of it. It comprises such topics as: "Introduction to microeconomics; Market economy system; Supply and demand; The production of economic benefits; Production costs and profits; Market models; Labour market; Income distribution; Capital and Land Markets" which were specially prepared for students by the lecturer of this subject, translated into English and checked up by the native speaker. It has the same material on "Microeconomics" that the students learned at their professional classes but in a concise variant. As for the methodological point of view the course provided the constant use of the lexical material under study in various semantic aspects in speech that is repeated from text to text. New lexical units from the first theme were involved into the second theme, new lexical units from the second theme – to the third theme, etc. They were used in different contexts and in various derivative forms (for example, to compete – competition – competitor – competitive), thus ensuring their multiple repetition, that is considered obligatory for the complete mastering of lexical material, according to Martynova (Martynova, 2016) theory because it does not allow words to be forgotten. The speech material increases from text to text, both in volume and in content. New words from all the following topics are added to the general list of words and also begin to be repeated from lessons to lesson. Such organization of the speech material helps the effective memorization of the linguistic units under study, their relatively complete mastering and the possibility of their use in various types of speech activity.

2.3 Procedure

The integration of a major subject and a foreign language is recommended to be implemented at three stages of the educational process. It requires definite strategies to maximise the students' mastering at each stage.

Training at the first stage is aimed at mastering the foreign language vocabulary with the help of which the major subject is expressed in English. This step is proved by the words of Cenoz (Cenoz, 2015) who indicates that the language of the subject content should be accessible and understandable to provide mutual interaction. The parts of the subject content and the sequence of their learning are determined by the teachers of the definite subject. Therefore, all foreign language activities in both the semantic and methodological aspects depend on the essence and scope of each part of the subject material under study. However, from the beginning of the integrated teaching, the knowledge of the foreign language means, with the help of which the subject content is expressed, is very limited, and the presentation of the professional information in a foreign language turns out to be impossible. That is why the speech potential of a foreign language at this stage is low. It corresponds only to the ability to perceive and comprehend the conceptual apparatus of the definite part of the theme, to explain the essence of the presented terminology and to demonstrate its understanding in mini-texts.

A foreign language dominates at this stage and is considered to be an educational objective. The professional subject is considered to be an educational means. Language units are extracted from the content of the major subject. At the language level, the units to learn are terms and set lexical and grammatical expressions. At the speech level, there are sentences with the help of which the concepts under study are interpreted, the essence of the laws under study is clarified, the meaning of any professional action is explained.

As for the methods of teaching, it is recommended to use the following ones at this stage:

1) presenting new professional concepts (for example, "expenditure, profits, revenue, bonus issue") using different techniques: a semantic concept map, multimedia presentation, explanation, demonstration the words use in different professional environments;
2) note-taking new concepts marking them with different colours;
3) defining new concepts;
4) comparing existing definitions of one concept given by different scholars;
5) explaining the difference in the formulations of one concept;
6) demonstrating the examples of use in different linguistic professional environments;
7) compiling semantic tables;
8) guessing the terminological riddles / crosswords;
9) writing the terminological dictations;
10) watching mini-video fragments selected by teachers where the new words are used in professional contexts.

The following visual aids must be obligatory used at this stage of teaching: tables, schemes, economic charts, multimedia.

Training at the second stage is aimed at perceiving and understanding the main content of the subject material under study presented in a foreign language. This professional material must not contain unfamiliar linguistic phenomena that allow students perceiving the material freely (the initial presentation of professional information occurs orally in the form of an interactive lecture). The integrated nature of such methodological actions is manifested in the simultaneous mastering of two subjects. On the one hand, students receive professional (major subject) knowledge, and on the other hand, they develop foreign language skills.

Thus, at the second stage, we have both educational and foreign language speech activities which act parallel. A foreign language and a subject of professional activity act both as an educational objective and educational means.

Educational activity as an objective is developing better at the expense of the subject knowledge, which is acquired by using a foreign language; and as a means, it presents a source of content for foreign language functioning. That is why the speech unit of teaching is a subject-oriented lecture material at the beginning, and then a written text, which, during the increase of the educational activities potential gradually reduces its level of adaptability to complete authenticity in the process of integrated teaching.

As for the synthesized methods of teaching, at the second stage it is recommended to use the following:

1) an oral presentation of foreign language lecture material;
2) note-taking of lecture material;
3) short answering to the questions on the text of lectures;
4) detailed answering to the questions on the text of lectures;
5) tests for understanding the material of the lecture;
6) reading a printed version of the text of the lecture;
7) writing down the main items of the lecture material;
8) analysis of the economic tables and diagrams;
9) having a talk on the content of the lecture;
10) watching a fragment of the recorded authentic version of the lecture from London Business School on the same topic.

The following visual aids must be obligatory used at this stage of teaching: tables of digital indicators of economic processes, schemes of economic processes, formulae for calculating economic efficiency, detailed plans of lectures (Baklanova et al., 2020).

Training at the third stage is aimed at the simultaneous development of skills for the practical application of professional and foreign language knowledge. The speech potential of a foreign language at this stage grows up to such an extent that it is used as a means of improving professional knowledge, as well as a means of using it in the practical training. At the same time, the students don't have to concentrate on the form of their thoughts but have to do it blindfolded. This fact, in its turn, allows having a complete focus on the content of the subject under study. Therefore, at this stage, a foreign language loses its targeted use. The educational activity, on the contrary, assumes the main accent. At this stage, two activities are equally implemented: educational – dominant and foreign-language – supporting. The educational action is planned, carried out and evaluated by means of a foreign language.

As for the synthesized methods of training at the third stage it is recommended to use the following:

1) searching new additional information on the topic under study, choosing the most important items and presenting them as a connected text;
2) describing textual and graphical information of economic indicators;
3) expressing opinions on a professional topic;
4) solving problem tasks and commenting on the process of their solutions;
5) modelling the real professional situations and their dramatizing;
6) preparing and presenting the report on the current economic situation in the country;
7) implementing the project tasks on the definite topic;
8) interviewing the representatives of financial structures;
9) conducting meetings with the leading specialists of the enterprises;
10) work with electronic cases based on the authentic documentation of the enterprises as a practical application of the obtained knowledge.

The following visual aids must be obligatory used at this stage of teaching: economic documents, graphs, tables, diagrams with digital information, video presentations, illustrating slides, electronic cases.

3 RESULTS AND DISCUSSION

The main indicators of the effectiveness of the offered strategies of integrating a major subject and a foreign language were the following: the quality of the foreign language proficiency, the quality of the professional economic knowledge mastering and the quality of the English speech development.

According to the results of the pedagogical experiment, we have found out that the students who were placed in the Experimental Group (EG), have achieved better results that the students of the Control Group (CG). They have progressed in developing their integrated skills and mastering:

1) professional terminology in English;
2) professional economic knowledge that corresponds to the content of their major subject;
3) fluency of the English-language speech (perceiving and understanding the English speech; producing a coherent, logical, lexically and grammatically correct English speech).

To measure the students' knowledge and skills, the assessment test was conducted. The following criteria were chosen: 1) linguistic (ability to produce adequately generally-used lexical units, economic terms / notions under study, terminological phrases and separate sentences on a certain professional topic and to find equivalents from their mother tongue) – maximum 30 points; 2) professional (the ability to understand and reproduce professional information in English according to the theme under study) – maximum 30 points, 3) communicative (the ability to communicate in English on the professional theme without preliminary preparation) – maximum 40 points. The indicators of assessment criteria of students' skills were measured by means of 100 scores according to the ECTS scale that uses gradation of A, B, C, D, E, F. The obtained data were analysed using Microsoft Excel.

The pre-test was held during class time at the beginning of the school year (September 2018). It was based on the English linguistic material and the professional topics that the students had learned the previous year according to their University curriculum. Ability to produce adequately the linguistic material under study was verified by means of translating the word combinations and sentences: a) from the English language into the mother tongue, that corresponds to receptive lexical knowledge; b) from the mother tongue to the English language, that corresponds to reproductive lexical knowledge. The following results were obtained: the average score of linguistic proficiency of the EG students was 50%, CG students – 51%.

The presence of professional economic knowledge was verified by means of doing the professional tests in English: a) to choose the correct answer of the given ones, b) to choose the odd variant of 4 given items, c) to explain in English the given professional terms or phenomena. According to the second criterion, the average score of EG students was 35%, CG students – 36%.

The ability to communicate in English on the professional themes was tested by means of such tasks: 1) to answer the teacher's questions on the professional topic, using the correct English language material and showing the professional knowledge; 2) to describe in English the professional information which is presented in a diagram/graph; 3) to compose a short report on one of the themes under study and reproduce it in English (not more than 10 sentences). The answers of the students were fixed by means of recording and later examined by the researcher and his assistants. According to the third criterion, the average score of EG students was 40%, CG students – 42%.

Table 1: Pre-test comparing EG and CG results, %.

Group	Linguistic	Professional	Communicative
EG	50	35	40
CG	51	36	42

The pre-test indicated approximately the same initial level of EG and CG students' language proficiency skills and professional skills.

At the end of the research the post-test on the students' integrated skills in English to prove the validity of the offered teaching strategies, was conducted. The students of EG and CG performed the identical tasks on the topics which both groups learned during the semester. The results are shown in table 2.

According to the linguistic criterion, 75% of EG students demonstrated the ability to produce adequately the linguistic material under study and 60% of CG students did it. According to the second criterion, 78% of EG students demonstrated the ability to understand and reproduce English professional information according to the theme under study and only 45% of CG students succeeded in it. According to the third criterion, 77% of EG students demonstrated the English speech development and only 58% of CG students succeeded in it.

The tasks that the students fulfilled according to

Table 2: Post-test comparing EG and CG results, %.

Group	Linguistic	Professional	Communicative
EG	75	78	77
CG	60	45	58

the third criterion at the post-test:

1) to answer 5 teacher's questions on the professional topic "Market economy system", using the correct English language material and showing the professional knowledge;
2) to describe in English the professional information which is presented in the given:"Cash" = 25000 ("Payments for wages") + 3500 ("Receivable of accountable persons") + 500 ("Administrative expenses") = 29000;
3) to compose a short report on one of the themes under study and reproduce it in English, for example, "Give the analysis of the financial system in the USA, the United Kingdom and Ukraine".

Judging on the obtained results it can be stated that there were differences between pre-test and post-test among all the groups of the research. From the post-test results of table 2, it is evident that the coefficient of learning was greater than 0.7 (70%) in EG in all the criteria (they were the following: 1 – 75%, 2 – 78%, 3 – 77%).

While the coefficient of learning in CG in all the criteria was lower than 0.7 (70%) (they were the following: 1 – 60%, 2 – 45%, 3 – 58%). The obtained outcomes of EG proved the effectiveness of the integrated teaching and its positive influence on professional knowledge development and foreign language proficiency. That means, according to Bespalko's knowledge diagnostics, the test is considered passed when the coefficient is > 0.7. It is considered reliable (Bespalko, 1989). The summarized comparative results are presented in table 3.

These summarized comparative results show differences between pre-test and post-test among all the groups of the research and make it possible to draw a conclusion that integrated teaching the English language and a major subject to the students majoring in economics improves the students' foreign language communication skills and professional skills.

At the end of the semester, the final questionnaire concerning the students' attitude to the conducted integrated teaching course was carried out. There were 4 questions which included such items:

1. How can you evaluate the conducted integrated course? (positive / indifferent / negative)
2. What positive things can you name after studying?
3. Did you understand the major material in English?
4. What difficulties did you experience?

On the basis of the questionnaire the following answers were obtained. As for the first question, 95% of students positively evaluated the integrated teaching technique (55% emphasized that they improved both language proficiency and professional knowledge; 23% stated that they started to understand the subject content much better; 9% said that they could easily make a professional report in English; 8% answered that they had already used English while interacting with foreign colleagues) and only 5% showed an indifferent attitude.

As for the second question, the positive things that students can name after studying are the following: increased motivation for learning English to understand the professional material in a foreign language (40%); dual-focused character of the teaching process (25%); unusual experience (20%); the feeling of self-perfection (10%); nothing interesting (5%).

As for the third question, the students gave such answers: I understood practically everything (15%), I understood the most part of the material (20%); I understood half of the material (40%); I experienced difficulties in understanding but I got the general ideas (20%); I understood practically nothing (5%).

As for the fourth question concerning experienced difficulties, the students mentioned such things: problems in listening to the material in a foreign language though in a written form I understood practically everything (45%), problems in quick writing the lecture in English (35%), problems in fluent answering in front of the group in a foreign language (20%).

Thus, the questioning also showed the effectiveness and the need of introducing integrated teaching into the educational process of Ukrainian tertiary schools. It should be noted that the final questionnaire acted only as a supportive means of proving the validity of the experiment and helped the researchers in evaluating the students' attitude to integrated teaching.

The obtained results give grounds to consider the developed strategies of integrated teaching both efficient and technological. Thus, during the experiment, the following strategies of the integrated teaching were set: 1) a systematic repetition of the linguistic and professional material; 2) the use of each language unit, which is under study, in its maximum possible linguistic and professional environments and in connection with the previously learned material in all kinds of speech activity; 3) the implementation of a major subject and a foreign language integration in the educational process of Ukrainian tertiary schools by means of three-stage work. At the first stage a foreign language dominates and is considered to be an educational objective; the subject of professional activity acts as an educational means. At the second stage a foreign language and a subject of professional

Table 3: Post-test comparing EG and CG results, %.

Group	Linguistic		Professional		Communicative	
	Pre-test	Post-test	Pre-test	Post-test	Pre-test	Post-test
EG	40	75	35	78	40	77
CG	41	60	36	45	42	58

activity act equally as an educational objective and an educational means. At the third stage the professional activity completely dominates over the foreign language activity and a foreign language only supports the professional activity performing.

Analyzing the existing points concerning integration content, it should be noted that Taillefer (Taillefer, 2013) states that language and non-language content do not dominate of one over the other; it is in balance, so that students could share their efforts and interests equally but the language needed depends on the content. Cenoz (Cenoz, 2015) on the contrary indicates that cognition competence should prevail over linguistic competence. We partially agree with both statements because in our opinion, the aim of the foreign language learning is not identical during the whole education period: at the first stage of learning, a foreign language dominates and is considered to be a main educational objective, at the second stage – both a foreign language and a major subject are in balance and don't dominate of one over the other; at the third stage – the situation changes cardinally, the subject content becomes a main educational objective and a foreign language starts playing only a supportive role.

This idea is disclosed by Gierlinger (Gierlinger, 2007) who identifies three issues of language: the language of learning; the language for learning and the language through learning. It means that the communication and language learning go far beyond just learning grammar rules or vocabulary and have different objectives at different stages of education. We completely support this idea and proved its validity and reliability by the present research.

4 CONCLUSIONS

The detailed analysis of scientific literature shows that integrated teaching has become an integral part of modern educational tendencies both in Ukraine and in the world, offering a wide range of possibilities for students. Such method opens up a new horizon for improving the Ukrainian education system and attention to diversity, as it provides resources and teaching aids with enormous potential for enhancing non-linguistic students' training.

The integration of a major subject and a foreign language is recommended to be implemented at three stages of the educational process. It requires definite strategies to maximise the students' mastering at each stage.

Having analyzed the existing ways of integrated teaching, the following advantages of its use were found out: raising learners' linguistic and professional competence without spending extra time to teaching two different subjects; increasing students' motivation to learning foreign languages and reflections on their professional experience; developing learners' cognitive flexibility, communication skills, professional interaction proficiency, and thus enhancing future economists' employability for the labour market and their chances to integrate into the world community.

Speaking about the methodological strategies, the following ones were developed and introduced into practice: a systematic repetition of the linguistic and professional material; the use of each language unit, which is under study, in its maximum possible linguistic and professional environments and in connection with the previously learned material in all kinds of speech activity; the implementation of a major subject and a foreign language integration in the educational process of Ukrainian tertiary schools by means of three-stage work. At the first stage a foreign language dominates and is considered to be an educational objective. At the second stage a foreign language and a subject of professional activity act equally as an educational objective and an educational means. At the third stage the professional activity dominates over the foreign language and the latter one only supports it.

Despite a great popularity of integrated teaching in the world, Ukrainian Universities don't participate in the international competition offering ETBs to students and still have curricula where major subjects and a foreign language are taught according to different syllabi, not having interdisciplinary connections.

Evaluating the effect of integrated teaching by the obtained results it was noted that all the students of the experimental group got more than 70% of the average score of in all the criteria: linguistic (75%), professional (78%) and communicative (77%) demonstrating good listening and speaking skills, knowledge of economic terminology, the terms variation and combination, skills of producing linguistic units at the level of the word, phrase and text within the scope of the material under study. The students were able to solve professional communicative tasks. In addition to mastering a foreign language, the students received profound professional knowledge in Microeconomics.

We see the perspectives of our future research in organizing the process of integrated teaching using computer-based learning technologies as a means of intensification of the teaching process.

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The Development of Creative Thinking as an Important Task of Educational Process

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Abstract: Current trends in improving the educational system involve the parallel acquisition of multifaceted knowledge, the maximum expansion of horizons and the preparation of students for the optimal choice of profession. Scientists and methodologists from many countries work in this direction. The solution of these problems is inextricably linked with the task of developing general intelligence and creative thinking. In this work the role of lateral thinking in the creative process is discussed. Lateral thinking is an important component of creative thinking. The article discusses the essence of lateral thinking and possible ways to test it. Here we discuss also the features of the probability distribution function for various psychological parameters characterizing the personality. It was noticed that the more universal the psychological parameter, the closer its probability distribution to the ideal normal distribution. It is shown that the probability distribution of the lateral thinking parameter is similar to the normal distribution of Eysenck's parameter for general intelligence. The latter indicates that lateral thinking is a fairly universal personality trait.

1 INTRODUCTION

Educational process is aimed not so much at the transfer of knowledge, but at the development of thinking (Dickens and Flynn, 2001) and, in particular, creative thinking (Chen et al., 2019; Vlasenko et al., 2020). In the new programs created in connection with the modernization of the education system, this is the central task. This means that the teacher, along with the knowledge of modern approaches to improving the education system, in particular the STEM methodology (Kramarenko et al., 2020; Lovianova et al., 2019; Ponomareva, 2021; Semerikov et al., 2021), should be quite familiar with the psychology of thinking and the nature of creative thinking.

The problem of personality testing has a long history. Since ancient times, the assessment and prediction of human capabilities has been of fundamental and practical interest. And in our time, the creation of psychological tests is an important task, which is a subject of numerous studies and discussions. The skill of a teacher to assess the abilities and creative potential of students determines the level of the educational process.

There are different approaches to testing the intelligence and specific abilities of personality (Jesson, 2012; Kaufman, 2009; Katsko and Moiseienko, 2018). They are widely discussed, criticized, and at the same time are often used to solve practical issues. For example, one of the popular is Eysenck's IQ test (Eysenck et al., 1985; Cahan, 2018) for assessing the general intelligence. Many studies have been carried out using these tests in various countries, and these results are reflected in a lot of publications (Cahan, 2018; Juškevič and Kopelevič, 1994). For this test the distribution of the probability of detecting a particular level of intelligence IQ follows a normal law.

The law of normal distribution means that the parameter values tend to concentrate around the value of the mathematical expectation. The degree of spread of a random variable relative to the mathematical expectation is determined by the variance. Any empirical distribution curve is characterized by two parame-

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ters: the coefficient, which determines the symmetry of the curve with respect to the mathematical expectation (A_s), and the coefficient of kurtosis (E_x), which sets the "sharpness" of the distribution peak. In the case of a normal probability distribution law (Gaussian curve) (Dickens and Flynn, 2001) $A_s = 0$ and $E_x = 0$. Psychological parameters characterizing personality are described by different laws of probability distribution.

The psychological characteristics of a person can be classified according to the degree of their universality. For example, general intelligence is certainly a fairly universal characteristic of a person. All people have a certain level of intelligence. (We do not consider options of pathological psychological characteristics.)

At the same time, general intelligence is formed on the basis of different individual abilities. The formation of general intelligence depends on memory (various types of memory), the peculiarities of thinking, in particular, creative thinking and other personality abilities. It is obvious that the normal law of probability distribution, which is fulfilled for the IQ parameter, is not necessarily the case for other (less universal) psychological characteristics of a person. Therefore, we can judge the degree of universality of the psychological characteristics of a personality based on the proximity of the distribution function of its probability to the normal law.

Let's look at some different examples. What is the probability distribution for those with musical memory? It should be noted that the perception of music and musical memory characterize the emotional and psychological sphere of the personality, to a large extent determining its psychological portrait.

Outstanding scientists saw in music the highest manifestation of human intellectual achievements. Gottfried Wilhelm Leibniz wrote in the letter to Christian Goldbach: "music is a secret arithmetic exercise of the soul, which calculates without knowing it" (Patel and Read, 1996). Helmholtz's research (Cahan, 2018) touched upon various scientific and practical issues related to the problems of perception, creativity, diagnostics of abilities, methods of musical education, which gave a powerful impetus to the development of almost all areas of musical psychology. At the same time, if to compare the distribution of the probability of manifestation of high general intelligence of IQ with the function of the probability of manifestation of musical memory, we can see significant differences (figure 1). They consist in the fact that in the latter case the coefficient of kurtosis EX differs from zero and the variance σ^2 is much less.

Let us turn to such a person's condition as depres-

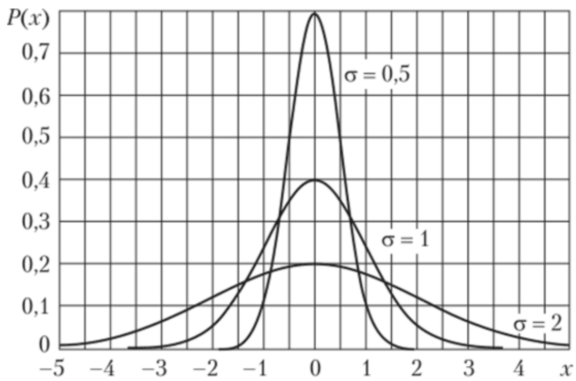

Figure 1: Illustration of the difference between the distribution curves for the parameters: IQ (σ =1), parameter of musical memory (σ = 0.5) (Stough et al., 1994), parameter of depression (σ = 2) (Mozhaleva, 2015).

sion. This condition is experienced by a significant proportion of the world's population. The probability distribution for carriers of this state differs from the normal law already in opposite signs: the distribution peak is sharply lowered, and the variance is sharply increased (figure 1).

In our work, we set out to investigate lateral thinking as an important component of creative thinking. Lateral thinking as a thought process was discovered by De Bono (De Bono, 2015). The essence of such a thought process is that we are distracted from the object in question and switch to another object, which at first glance has nothing to do with the first. However, after such a transition, completely new possibilities of considering the first object open up. Albert Einstein said that life is like a bicycle: "as soon as you stop pedaling, you fall" (Einstein, 2016). This is a good example of lateral thinking.

Somebody think that a creative process is better described as a process of logical thinking, trial and error, feedback, and reflection. We do not reject such opportunities. However, there are many people whose experiments and articles show that training and developing lateral thinking leads to an improvement in the emergence of creative solutions in standard or stressful situations (Mellenbergh, 1989). There are guidelines for developing lateral thinking. But in order to track the development of lateral thinking, there is a need to measure it.

It is known that all scientific research tends to use models. Lateral thinking is manifested in this. The scientific result depends on a well-chosen model. The famous models are used in the natural sciences, in particular, in physics: models of atom, atomic nucleus, crystal etc.

In cosmology, models of the Universe are being widely studied and discussed.

Our work is aimed at drawing attention to the problem of the development and use of lateral thinking. A task set to compile a questionnaire to test lateral thinking. An experiment was carried out with groups of students and engineering workers. The probability distribution functions for the studied groups are obtained and analyzed.

2 TESTING LATERAL THINKING

Among the tests designed to assess the parameters of thinking, very little are used to determine the level of lateral thinking. This is due to the fact that some psychologists underestimate the role of lateral thinking in the creative process. However, understanding the essence of lateral thinking and its development in students is necessary to increase the creative potential of the individual. A possible approach for assessing the level of lateral thinking is proposed below.

2.1 Test Questions Formulation Principle

In the case of lateral thinking, unobvious special "associations" take place. These are associations that are not caused by the external similarity of objects. In this case, objects and phenomena are compared on the basis of the subjective view of a person having his vision. A typical example is the creation by physicists of a model for the fission of an atomic nucleus. Frenkel and Weizsaeker "saw" in the atomic nucleus a drop that drains from a drainpipe during rain (Frenkel, 1996). The picture of the separation of a drop from a pipe led to the thought of a drip mechanism of nuclear fission. The drop model of the atomic nucleus is described in all textbooks on nuclear physics (Hawking, 2018). The question of interest is of the extent to which lateral thinking is present in human thinking at various levels. In drawing up a questionnaire for assessing lateral thinking, we chose triads of words in which two words are far from each other in content, and two words are close. It is proposed to determine two words that at first glance are in no way linked associatively and try to find in these words something common. The questionnaire is attached in figure 2. It has been checked in accordance with the requirements to tests (section 2.3).

2.2 Description of Experimental Results

For the study, 3 groups of subjects were selected, of which two groups were students (140 and 70 people) aged 19–22 and a group of engineers and technicians (56 people) aged 30–45 years. A questionnaire was used to assess the level of lateral thinking (figure 2). The content of the questionnaire and the principle of assessing the correctness of the answer are described above.

No suggested choices for matching word pairs were provided. It was suggested to make an appropriate choice of two words and in each case provide a short justification for the choice made, similar to those on the right side of the figure 2. The choices made and their rationale may not be the same as those suggested in figure 2.

The ratio of the number of (n) triads in which the corresponding pairs of words were correctly selected to the total number (N) of triads (in figure 1) was used as a parameter characterizing the level of lateral thinking ($LT = n/N$).

Using the obtained data, in all cases the parameter distribution characteristics were calculated: average values of the measured value ($\bar{x}$), mathematical expectations (μ), standard deviations (σ), third moment of inertia (μ_3) and fourth moment of inertia (μ_4). The results are shown in table 1.

Table 1: Characteristics of parameter LT distribution for studied groups.

Number of group	$\bar{x}$	σ	μ_3	μ_4
1	0.43	0.65	0.05	0.48
2	0.37	0.68	0.10	0.44
3	0.32	0.54	0.02	0.42

Using the data in table 1, we calculate the values for the coefficients of skewness (A_s) and kurtosis (E_s): $A_s = \mu_3 \ / \ \sigma_3$ and $E_x = (\mu_4 \ / \ \sigma_4) - 3$. The results are presented in table 2.

Table 2: Values A_s and E_x for studied groups.

Number of group	A_s	E_x
3	0.7	-0.53
1	0.18	-0.18
2	0.32	-0.98

Figure 3 shows the experimental distribution of the parameter LT for the first group.

2.3 Checking the Applied Test

2.3.1 Validity of the Test

Validity is checked as the correspondence of the measured parameter to the psychological characteristic that is being studied. In our case, we are talking about the assessment of lateral thinking. Therefore, during the testing process a survey was conducted to find out

River	Sunset	A life	The flow of the river is usually associated with the flow of life, but in the case of lateral thinking, the combination "Sunset of life" is applicable.
Crimes	Hurricanes	Cataclysms	Hurricanes and cataclysms are related concepts, but crimes as cataclysms are a lateral vision of the subject.
Hunger	Loneliness	Insulation	Loneliness and isolation are close concepts, but a person who thinks laterally understands loneliness as a hunger for communication.
Eye	Sadness	Depth	The expression "sad gaze" is often encountered, but the expression "deep gaze" already indicates more lateral vision.
Mountain	Barrier	Patience	Climbing the mountain naturally requires preparation and patience, but overcoming any barrier also requires preparation and patience.
Needle	Spark	Think	Thought flares up like a spark, and sometimes pierces like a needle.
Cloud	Sea	Sky	The sea is usually associated with the sky, but in the case of lateral thinking, a person compares the sea with a field (he sees wheat stalks swaying in the wind).
Wind	Hurricanes	Think	The wind is naturally associated with hurricanes, but it happens that "the wind walks in the head."
Face	Portrait	Decision	The face is naturally associated with the portrait, but you can talk about a decisive facial expression.
Find	Art	Eureka	Eureka is the intuitive finding of a solution, also an unexpected image in art.
Science	Target	Vertex	Science is aimed at achieving a specific goal, but it is also the pinnacle of human intellectual activity.
Song	Soul	Life	Of course, there is the soul in the song, but spirituality is the basis of life.
Thoughts	Mysteries	Horses	There are secret thoughts, but you can imagine "thoughts - horses".
Steps	Tops	Run	Running is quick steps, but steps can be thought of as moving to the top.
Road	Lights	End	The road is usually associated with road lights, but in the case of lateral thinking, the words "lights" and "end" are chosen (light at the end of the tunnel).
Poems	Formulas	Regulations	Formulas describe laws, but poetry obeys its own laws.
Friend	Present	The God	The best gift from God is good friends.
Libra	Character	Sensitivity	It is important to have a sensitive scale, but also a sensitive character.
Neighbor	Character	Enemy	The enemy can be a neighbor, but also your own character.
Rescue	Berry	Horse	Both a horse and a berry can save.
Wood	Family	House	The family is associated with the home, but there is also a family tree.
Chord	Disappointment	Note	A chord is associated with a note, but there is also a "disappointment note".
Bicycle	A life	Snake	Life wriggles like a snake, but "looks more like a bicycle" (A. Einstein).
Bonfire	Fire	Ice	Bonfire is associated with a fire, but "ice and fire" appears in poetry (A. Pushkin)
Autumn	Evening	Sunset	Evening is associated with sunset, and in the case of lateral thinking, autumn is perceived as sunset of the year (or sunset of life).

Figure 2: Questionnaire for testing lateral thinking. The words of the recommended choice are underlined.

what unity of the chosen word pairs a person implied. In order for the correct result to be counted, it was necessary for the test taker to explain his choice in the spirit of the comment in figure 2. It was not necessary that this explanation coincided with the comment in figure 2. The main requirement was that the original vision manifested the subject in the interpretation of the unity of the objects being compared. Situations arose when the subject chose objects that had obvious commonality, but at the same time a "lat-

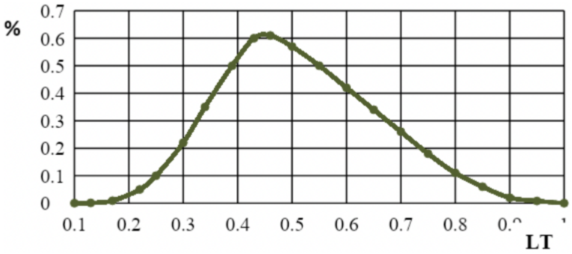

Figure 3: Experimental distribution of the parameter *LT* for the first group.

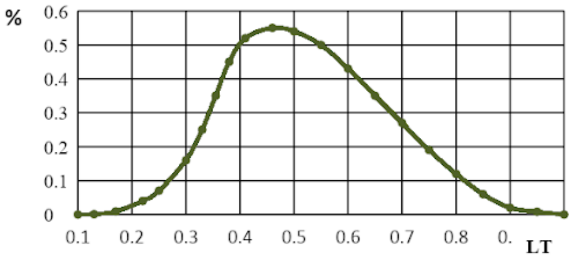

Figure 4: Experimental distribution of the parameter *LT* for the second group.

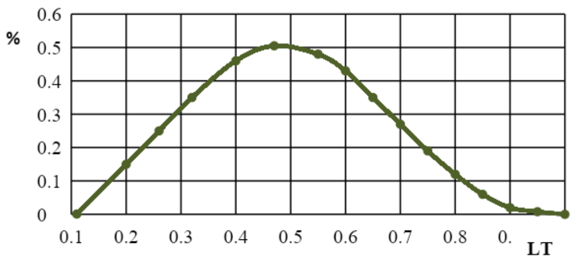

Figure 5: Experimental distribution of the parameter *LT* for the third group.

eral" vision was manifested and the unity of objects was noted that could not be noticed by another person. Thus, for each subject in all three groups, the parameter $LT = n/25$ was determined.

2.3.2 Test Reliability

Reliability of the test involves obtaining close results in repeated measurements as well as for subjects whose parameters differ little. To check the test reliability, we conducted testing of studied groups at different times with an interval of two-three months. We obtained similar test result as a result of multiple measurements of the parameters of the same group. Discrepancies in the parameters of the various groups also persisted.

2.3.3 Representativeness of Test

Representativeness suggests that test results obtained for a specific group of people represent the large part of population. To check the compliance of the test with this characteristic, we have taken two groups with twice as different the number of subjects (70 and 140). In both groups, the contingent is selected with close characteristics (educational level, professional qualifications, etc.). We obtained that in these groups the experimental results for the studied parameter (*LT*) differ slightly (table 1).

2.4 An Example When Studying Vacancies in Crystals

When studying the real structure of crystals, the concept of a vacancy (an empty place from which an atom left) and an interstitial atom (an atom that left its place with the emergence of a vacancy) are introduced. If an atom leaves close to its vacancy, a so-called Frenkel pair is formed. However, an intermediate variant is possible, when the atom does not move far enough from the vacancy, and the vacancy pulls it back in. When this process is repeated, a so-called "blinking vacancy" appears. Such a vacancy either appears or is "healed" by the returned atom. The concept of a "blinking vacancy" appeared relatively recently (Paritckaia et al., 2018). Physicists came up with the idea of a blinking vacancy by observing raindrops falling on the calm surface of a river. Raindrops leave a mark on the water, which disappears with a blink. This is a typical example of lateral thinking, just like in the case of nuclear fission above (Hawking, 2018) (figure 6).

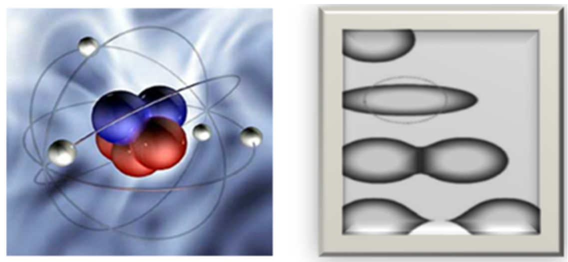

Figure 6: Illustration for the droplet model of the fission of an atomic nucleus. Left – an image of an atomic nucleus, on the right – an image of fission of a liquid drop.

3 DISCUSSION OF RESULTS

The problem of thinking, which is one of the central problems of psychology, is given little attention in addressing issues of improving the system of education, new methodological approaches, and developing new curricula. Despite the ambiguous attitude of psychologists and teachers to existing models and ideas about the mechanisms of thinking, it is useful to take into account the use of accumulated experience and ideas in the educational process. The concepts of productive thinking introduced by Wertheimer (Wertheimer, 2020), the concepts of lateral thinking introduced by De Bono (De Bono, 2015) and other well-known models of thinking (Young, 2008), must be taken into account in the learning process, when solving specific methodological problems. The teacher's attention should be focused not only on effectively communicating knowledge, but on choosing a teaching method that develops thinking. Therefore, it is important to be able to assess the student's ability to a certain type of thinking.

In this work, we investigated the possibilities of objective assessment of lateral thinking. Testing this type of thinking requires special care, since it is not about solving specific tasks. It is required to trace the course of a person's thinking and to distinguish the degree of originality of various approaches to the assessment of the meaning of concepts.

In many cases of life, a person is faced with the need to apply lateral thinking, in scientific research, in the perception of humour and simply in everyday life. When compiling a questionnaire for assessing the level of lateral thinking, we tried to give the subject the opportunity to find a wide range of associations.

The proposed test has been verified in terms of validity, reliability and representativeness. During the experiment, however, an additional approach was applied to assess the significance of this test. It is known that the probability distribution of detecting a certain value of the measured parameter during testing is typical for a particular test. In the case of measuring the IQ parameter, this probability distribution obeys the normal law. The IQ parameter is a fairly universal characteristic of a person. This parameter characterizes any person (except for pathological cases). It can be assumed that the closer the probability distribution of a given parameter is to the normal law, the more universal psychological characteristic is this parameter.

In the case of testing lateral thinking, an insignificant deviation of the measured empirical distribution of the probability of the *LT* parameter from the normal law was revealed, which indicates a fairly high universality of this personality characteristic.

4 CONCLUSION

The possibility of assessing the level of lateral thinking using the proposed verbal test is shown. The compiled questionnaire is a set of triads, in which each triad includes three words, of which two words are outwardly in no way connected in meaning. The task is to select these two words that have no outwardly any semantic connection and find something in common in these words. It is also required to briefly explain what exactly was found in common in the selected words. An experiment was conducted with the proposed test, in which two groups of students (140 and 70 people) and a group of engineering and technical workers (56 people) took part. As a result of processing the results, the values of the asymmetry and kurtosis coefficients were obtained, which characterize the deviations of the obtained empirical distributions of the probabilities of detecting the parameters of LT from the normal law. These deviations were found to be small.

It is known that when testing general intelligence using the Eysenck test, the probability distribution for IQ parameter obeys the normal law. Since the IQ parameter is a fairly universal characteristic of the personality, it is suggested that rather general personality traits are manifested also in lateral thinking.

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Modern Information and Communication Technologies in Professional Training of Sociology Students: The Mainstreaming of the Needs and Significance

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Abstract: The article presents an overview of the main possibilities of using information and communication technologies in applied sociology, as well as the urgent need and importance of computer training of the students. Filed the results of comparative analysis of universal, semi-universal statistical packages of computer processing of sociological information and professionally focused software products on the market today. Outlining the advantages and disadvantages of their use in empirical sociology to describe the quantitative and qualitative characteristics of objects of study, explanations of causality, forecasting of social processes. Characterized by modern information technology used for collecting and storing social data. It is proved that the leading component of the computer literacy specialist-sociologist is the formation, the development of algorithmic thinking, the ability to make the right choice in favor of a software package that satisfies all the requirements, and that would efficiently and professionally perform all the tasks of an applied nature.

1 INTRODUCTION

Training specialists in humanities in Ukraine, in particular sociologists, given the growing need for sociological interpretation of contemporary problems and events, requires significant improvement of the educational process of their training in institutions of higher education.In accordance with the standard of higher education in Ukraine training of bachelors of sociology in the field of knowledge 05 “Social and Behavioral Sciences”, specialty 054 “Sociology” (MON, 2020) should be based on social sciences and humanities. However, the mathematical component of vocational training is no less important.

The process of studying complex mass socioeconomic, socio-political, socio-cultural phenomena and processes can not be limited to theorizing. It involves mathematical formalization, modelling of social reality to formulate accurate, well-grounded conclusions about the situation. Undoubtedly, various mathematical procedures are necessary, on the one hand, due to the current stage of social processes development, the dynamics of social transformation. On the other hand, implementation of social management, forecasting is impossible without deep knowledge of gathering, processing and analysis of sociological information. These are mathematical methods that already have a wide range of applications. In this regard, actualized the need of introduction of modern information and communication technologies in the process of professional training of future sociologists.

The use of mathematical methods in sociology began long before the computer age. In the second half

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of the twentieth century, the possibilities of the mathematical apparatus expanded dramatically due to the development of information and communication technologies. Today, there are software products aimed at solving sociological problems, but they are not fully used by sociologists-practitioners. They simply do not like mathematics. On the other hand, not all software products available for use a wide range of users, proceeding from their high cost , the system requirements for their installation, the need for special skills, knowledge of the language of the interface. Tatarova (Tatarova, 2018) spoke very aptly about the problem of teaching quantitative methods for sociology students, noting that “they are allergic to formulas and graphs”. However, there is an urgent need to form digital literacy due to the fact that modern sociologist can not do without mathematical formalization, without computers in the use of not only quantitative but also qualitative methodology and techniques of collecting empirical sociological material.

The formation of digital literacy is a continuous process that begins with the study of such disciplines as “Fundamentals of Informatics”, “Mathematical and Statistical Methods in Sociology”, “Social Statistics”, “Selective Method in Sociology”, “Methodology of Sociological research” and logically continues during the course “Analysis and computer processing of sociological information”. This type of functional literacy should be understood as the level of students awareness about the possibilities of using computer software to solve standard professional problems. Based on the content of the latter, all information technologies used in applied sociology should be divided according to their functional purpose into three groups: programs for processing sociological data, collection, storage and presentation of the results.

Tatarova (Tatarova, 2018), Tolstova (Tolstova, 2015) studied the problems of mathematical and digital competencies formation of future sociologists in their works. The use of information and communication technologies in applied sociology is shown in (Borovikov, 2003; Bühl and Zöfel, 2002; Filipova, 2001; Gorbachik, 2004; Mayer, 2015; Panchenko et al., 2020, 2021; Tsypin and Sorokin, 2016; Tsyuhai, 2010). However, in most works, the researchers focused on the features of only one or more of the software products. Today, in the literature on sociology there are almost no publications that would contain a comprehensive review of existing software packages outlining their leading advantages and disadvantages. It would make it easier for a sociologist-practitioner to choose a program at one stage of empirical sociological research according to the research objectives. Therefore, this article aims to review the main opportunities of information and communication technologies in applied sociology at the stages of collection, processing and storage of sociological data, as well as to determine the actual needs and importance of the digital component in the training of sociology students. The main criteria for the selection of software products for further analysis were the availability (presence or functionally free demos) and Ukrainian/Russian interface.

2 INFORMATION TECHNOLOGIES FOR COLLECTING SOCIOLOGICAL INFORMATION

Regarding modern information technologies for collecting sociological data and their capabilities, we note that there are at least ten most common services for empirical sociological research: e-mail; placement of text questionnaires in newsgroups; internet forums, teleconferences (bulletin boards); webpages of polls; online focus groups; CAWI (Computer Assisted Web Interface) – online survey using web-resources without the participation of a researcher; TAPI (Tablet Assisted Personal Interviewing) – tablet survey; CATI (Computer Assisted Telephone Interviewing) – automated telephone survey system; CAPI (Computer Assisted Personal Interviewing) – electronic questionnaire via email services or sites with the participation of the researcher.For author’s research it is enough to use such services as Survio (survio.com), SurveyMonkey, Simpoll (https://simpoll.ru/), Multi-platform Social Media Surveys (https://www.twtpoll.com/), Google Forms, Microsoft Office (Excel) and others (Geger et al., 2015).

E-mail survey is a rapid and easy way to work with the target audience of informants, for example during expert evaluations. In the vast majority of cases, this information and communication service is used to send invitations to participate in Internet forums, teleconferences or focused group interviews. The main problem is the inability to record the reluctance of potential respondents to participate in the study, as well as the reasons for their refusal (Filipova, 2001).

However, online research in newsgroups is more attractive. It is an interactive or autonomous survey of people united by common interests on specific issues of social life. Internet forums and teleconferences can be considered as varieties of such a survey. Their advantage is the ability to use open-ended questions, unstructured or semi-structured questionnaires.

Web-pages of surveys are ordinary questionnaires in HTML-format, which are posted on the WWW. Their widespread use is complicated by the lack of technical skills, as the construction of such questionnaires is made with the help of a scripting language (GGI) which automatically processes all the data obtained (Filipova, 2001).

All modern information platforms for conducting online surveys Survio (https://www.survio.com/en/), SurveyMonkey (https://www.surveymonkey.com/), Simpoll (https://simpoll.ru/), Multi-platform Social Media Surveys (https://www.twtpoll.com/), Google Forms (https://www.google.com/forms/about/), Microsoft Excel (https://office.live.com/start/excel.aspx) differ in functionality in terms of the number of questions types, the availability of directory service, ways to attract respondents, services for automatic results processing, graphical representation of reports, feedback from the researcher to respondents, and the availability of paid/free services.

Empirical research conducted via the Internet has a number of obvious advantages: technical parameters (savings in resources compared to traditional forms of population surveys); large sample size (low level of material costs per respondent allows you to maximize the sample size, thereby reducing the amount of random measurement error); the speed of the survey (a large-scale, global online survey of several thousand people around the world can be conducted in a few days); the possibility of rapid response (combination of laboratory and field stages, making adjustments to the tools); wide coverage of both the research audience and study topics; relevance (when conducting online surveys, the effect of the interviewer is completely excluded); organizational flexibility (the respondent chooses a convenient time and place for filling out the tools); automatic data recording and their initial analysis, etc. However, such shortcomings and limitations as lack of representativeness (online research data cannot be extended to the entire general population, but only to network users, in addition, due to the rapidity of informatization processes, the general totality of users is constantly changing); spontaneity of the sample (as a rule, only willing users answer the questions of the tools posted on the network. It is a “self-selection method” which further complicates the ability to control the compliance of the sample and the general totality); lack of possibility to establish the fact of unique participation provided anonymity, in particular multiple participation; the difficulty of verifying the accuracy of the data obtained; technical restrictions on the number of questions, their length; lack of possibility to provide supporting information, explanations in case of incorrect interpretation of the questionnaire by the respondents, control of omissions of certain questions, etc.

3 UNIVERSAL/SEMI-UNIVERSAL SOFTWARE PRODUCTS FOR THE SOCIAL DATA PROCESSING AND THEIR SIGNIFICANCE IN THE FORMATION OF COMPUTER COMPETENCE OF FUTURE SOCIOLOGISTS

While conducting empirical sample studies, sociologists have to process large arrays of primary data. Carrying out such full-scale works takes a lot of time and requires considerable effort. Probabilistic-statistical methods and models are applied to general totality in order to extrapolate the conclusions obtained during the study of a sample of social objects. According to Tatarova (Tatarova, 2018), the main condition for their use is the assumption of at least approximate observance of the properties of the so-called statistical ensemble: the possibility of repeated observations under the same conditions; the presence of a large number of random factors that characterize the conditions of observations, which do not allow to make deterministic conclusions about whether or not will occur as a result of these experiments.

Speaking of application program packages designed for processing sociological data, we note that there are universal/semi-universal (in terms of their functional purpose, applicability and technology of calculations almost does not depend on the subject area of research) and professionally oriented (aimed at processing sociological information that allows to identify patterns against the background of coincidences; to make sound conclusions, forecasts and assess the probability of their validity). Until the 1990s, most domestic sociologists carried out empirical research and used mostly questionnaire methods to collect data. Computer programs developed up to that time were based on the statistical approach. However, the wide interest in the use of quality methods necessitated the development of adequate specialized analytical software for their processing. Currently, available software products can also be classified based on data they process (or data obtained using traditional

Table 1: The comparative analysis of online services for surveys.

Features / Services	**Survio**	**Survey Monkey**	**Simpoll**	**Multi-platform Social Media Surveys**	**Google Forms**	**Microsoft Office (Excel)**
The base of respondents	+	-	-	+	-	-
Services automatic processing of the obtained results	+	+	+	+	+	-
Graphics	+	+	+	+	+	+
Changing the settings, design	-	+	+	+	+	+
Service support	-	-	-	+	+	+
The possibility of using mobile devices	+	+	-	+	+	+
Availability (free version, demo version)	-	+	+	-	+	+

quantitative or qualitative methods of collecting sociological information). However, since there is no clear distinction between the latter in applied sociology and taking into account that any qualitative information can be digitized, this classification is less successful. As for the classification by functional purpose, the first group includes software products such as OCA, Vortex 10.7, IBM SPSS Statistics 26, Stadia 8.0, Statistica 13.3, StatPlus 5.0, DA-System 5.0 and others, the second group – SociometryPro 2.3, ContentAnalyzer 0.52, TextusPro 1.0, TextAnalyst 2.01, WordStat 1.1 etc. We will consider each of them in detail separately.

To find answers to relevant research questions, the sociologist is faced with the task of choosing an optimal statistical package from the available universal or semi-universal ones. The best option is one that combines the necessary functionality, high-quality work and a reasonable price. When choosing an application package, it is necessary to take into account, first of all, its conformity with the tasks to be solved, the amount of processed data, the requirements for the available computer equipment.

Most of the statistical packages presented on the market today have a flexible modular structure that can be supplemented and expanded by user modules, which are additionally purchased or available for free access on the Internet. Such flexibility allows you to adapt most packages to the needs of a particular sociologist.

A sociologist who organizes the applied research must determine the list of tasks and agree them with a client before choosing a package of applications to process sociological data of. In research practice, the main three types of such tasks are most common:

1) description of the object (collection of quantitative and qualitative characteristics), which allows you to form a general idea of the object of study, to compare two or more objects. It is a statistical analysis of data. To implement this research task, the following statistical indicators are used: arithmetic mean, mode, median, deviation, standard deviation, dispersion, measures of variation (range, maximum, minimum, average linear deviation, standard deviation, oscillation coefficients, relative linear deviation), etc. The procedure of statistical analysis is key to clarify statistical patterns, test hypotheses about the presence and nature of dependencies;
2) explanation of causal relationships – correlation, regression, factor, variance, latent and other types of analysis, construction of one-, two-dimensional tables of data distribution;
3) forecasting of socio-economic processes – the processing of time series, construction of regression equations, trend calculations (patterns of development), modelling, extrapolation, etc.

The most universal data processing program is SPSS (the software name originally stood for Statistical Package for the Social Sciences, reflecting the original market, then later changed to Statistical Product and Service Solutions) has been developed in 1968 by three PhD students at the University of Stanford (Norman H. Nie, C. Hadlai (Tex) Hull and Dale H. Bent). The latest version of IBM SPSS Statistics 28 was released in May 2021. Its main advantages are a developed apparatus of statistical analysis, versatility, a wide range of graphical procedures, reporting tools, high computing speed, simple and user-friendly multilingual interface, detailed context-oriented help system. Disadvantages of the program include high computer requirements (1.56 GB of RAM, 1.11 GB of hard disk memory and a processor with a frequency of 1 GHz and above) and pricing policy compared to statistical packages of the same level (Bühl and Zöfel, 2002).

In Ukraine, the first application package ("OCA" – processing of sociological questionnaires) was developed in 1989 by A. Gorbachyk with the support of the Institute of Sociology of the National Academy of Sciences of Ukraine. It is designed to organize the introduction and statistical analysis of the results of various sociological surveys (Gorbachik, 2004).

A new updated version of OCA for Windows appeared in 2001, in 2004 – OCA New Line, and in 2019 – OCA CATI Android. The package provides all basic operations with numerical data sets, in particular, input of questionnaires, logical control of entered information, construction of filters for selection of questionnaires under a certain condition or random selection, tables of one-, two-dimensional distribution, calculation of central trend measures, variations and indicators of connections, calculation of sampling and error, testing of statistical hypotheses, implementation of factor and cluster analysis, construction of linear regression equations, etc. The main advantages of this Ukrainian software product are the conciseness of the interface, relative cheapness, while the main disadvantage is the limited functionality.

D. Shkurin (Ural Federal University named after A. M. Gorky) created the first version of the Vortex program in 1994. The latest updated version of the program appeared in 2013 (Shkurin, 2016). It is a modular program based on a data entry module. There are different versions of the program which differ in functionality: basic (data entry module, basic functions); professional (data entry module, basic functions, professional functions); full (data entry module, basic functions, professional and additional functions); student, academic and version for educational institutions. There may be separate subprograms such as the module for conducting personal interviews, FTP-server for conducting surveys, the master of digitization of the territory map, the module of pasting files, etc. Additional features of the Vortex program include the ability to process data collected during surveys by the following means: CAWI (Computer Assisted Web Interface); CATI (Computer Assisted Telephone Interviewing);TAPI (Tablet Assisted Personal Interviewing);CAPI (Computer Assisted Personal Interviewing). Unlike other software products, it has the option of developing data collection tools (questionnaire, interview or testing form, etc.).

The Stadia (Statistical Dialogue System) program was developed by A. Kulaichev in 1985 (Kulaichev, 2013). The program provides comprehensive data analysis using a set of modern and effective methods for determining descriptive statistics, criteria for difference, categorical, variance, correlation and regression analysis, to visualize the data by means of business and scientific graphics. Its main drawback is the inability to process data presented in nominal scales with compatible alternatives, as well as the option to export / import data with other statistical packages of applied programs.

Universal statistical package Statistica was developed by StatSoftInc in 1991 (Borovikov, 2003). Its latest 14th version was released in 2020. In addition to the generally defined statistical and graphical tools, the system has specialized modules, for example, for sociological or biomedical research, for solving technical and industrial problems as construction of quality control maps, process analysis modules and experiment planning. Similar to Stadia, this software product does not have the ability to process sociological variables on a nominal scale with compatible alternatives. The advantages of the package include: the ability to exchange data with MS Windows applications, analysis results can be displayed in the form of graphs, tables and text files, macro recording to automate the same tasks, the ability to process a database of 32,000 variables and almost unlimited observations, the ability to build 2D, 3D and 4D graphs, matrices, icons.

The StatPlus application package was developed by AnalystSoft in 2006 and the latest version appeared in 2016. It allows the calculation of basic descriptive and non-parametric statistics; it is possible to import/export documents in Microsoft Excel, StatSoft, SPSS, etc. However, its options are very limited for the main tasks of empirical sociological research compared to other software packages (Tsyuhai, 2010).

The DA Standard 5.0 (determination analysis of data) was developed in 2011 by Context Media to process the results of marketing and sociological research, financial data of the company's activities, etc. The system software contains two programs – DICT (provides data preparation for processing, input of variables vocabulary and data, export/import of data) and DA (designed for data analysis, linear and even distributions, multidimensional determination tables, subsample formation, construction of new variables, etc.). The program is built as a traditional database (there are tables for storing information and query system, which is intellectually built into the arrays of tables) (Context Media, 2011). Its advantages are adaptability to marketing problems, simple interface, low technical requirements. However, it works only on the basis of Windows 95, 2000, NT, XP; it has a special format for data storage, the lack of ability to export/import data with other statistical packages.

Summarizing, we note that the universal versatility of the packages enables the analysis of different data types using a wide range of statistical methods. Most of the existing software products have some built-in statistical procedures and are competing against each other. Their main difference are the ways in the interface.

The software packages are almost identical in their function, the amount of input data is limited by the capacity of computer memory that allows you to use them to conduct large-scale sociological studies. Compared to other Vortex has the advantage regarding the possibility of the formation of research tools and automatically create a dictionary of variables for further input and analysis of the array data. But OCA unlike other software has the ability to process data presented in a nominal scale with compatible alternatives. SPSS is the only one among the presented software has capabilities of rendering 3D graphical images. All the packages are paid and have trial versions available to download on official sites.

Next, consider a professionally-oriented (specialized) packages.

So, the program SociometryPro 2.3 has a special purpose. It is created by the specialists of LeDiS Group (Moscow, Russia) to simplify the processing of sociometric survey data (LeDis Group, 2017). There is a Ukrainian analogue of the program. It is called "Sociometry" developed by the Academy of Information Technology. This software product allows you to create a database of sociometric research, calculate group and individual sociometric indices, to visualize the results in the form of targets and graphs.

We will focus on a few available text analyzers that have the ability to implement the quantitative component of content analysis of text documents. Textus Pro 1.0 is one of the simplest text analysis programs created by D. Kaplunov and D. Abramov. The main objectives of the program are: to calculate the use of keywords, their frequency and density; determining the number of words and symbols in the text (with spaces and without); analysis of the "nausea" of the text; calculation of the cost of the text based on the initial price per 1000 symbols of text analysis specified by the user (Chernyatinskiy, 2020).

The program TextAnalyst 2.01 is a tool for analyzing the content of texts, meaningful search for information, the formation of electronic archives. It was developed in 1991 by the specialists from the innovation center "Microsystems". The program options allow text analysis with automatic formation of a semantic chain with hyperlinks, meaningful search of text fragments by constructing a hierarchical tree of topics, text abstracting, clustering of text information by constructing a thematic tree, forming a hypertext structure.

WordStat2.0 is a free utility software for quantitative analysis of text submitted in html and txt formats. It was developed by O. Dubinskyi in 2001. The advantages of this program are the ability to combine similar words, despite changes in word forms, as well as the accumulation of measurement results. As a result it simplifies work with large arrays of information (Dubinskyi, 2019).

ContentAnalyzer 0.52 was developed in 2005 by the specialists from the Elibriz Software company. It is aimed at analyzing thematic web-documents on the number of keywords and their word forms and creating an abstract. The program contains an integrated interface, calculates the coefficient required for structural analysis of documents (Mayer, 2015).

In conclusion, we note that the main feature of specialized packages is the presence of functional limitations relative to the analysis of the data associated with the specific method of collection of primary sociological information. The use of this type of product requires the user knowledge of the list of statistical procedures characteristic for a specific method, which, of course, becomes an obstacle to their mass usage.

4 INFORMATIZATION OF THE PROCESS OF PRESERVING SOCIOLOGICAL INFORMATION: EUROPEAN AND UKRAINIAN EXPERIENCE

Another area of using information and communication technologies in applied sociology is the preservation of data in the format of archives, information banks (big data).Their main functions are quite clearly defined: the development of methods and means of accumulating sociological information; standardization of methods; information and reference support for sociologists; coordination of sociological research; exchange of primary empirical data; creating conditions for secondary and comparative analysis of data; carrying out settlement and computing operations at the request of users.

The ultimate goal of working on the sociological archive and sociological information bank is to transform it into a transnational center for the exchange of social information to attract a wide range of specialists (scientists, politicians, journalists, NGO activists, government officials) to in-depth systematic analysis of various aspects of society.Due to the constant replenishment of the archive, it is advisable to introduce a special bulletin. There will be along with informa-

Table 2: The comparative analysis of universal/semi-universal statistical packages.

Features / Program	SPSS	OCA	Vortex	Stadia	Statistica	StatPlus	DA Standard
Forming tools	-	-	+	-	-	-	-
Basic statistical methods	+	+	+	+	+	+	+
Filter data	+	+	+	-	-	-	+
Linear modeling	+	+	+	+	+	+	-
Multidimensional modeling	+	-	+	-	+	+	-
Nonparametric methods	+	+	+	+	+	+	-
Correlation analysis	+	+	+	+	+	+	+
Factor analysis	+	+	+	+	+	+	+
Cluster analysis	+	+	+	+	+	+	-
Verification of statistical hypotheses	+	+	+	-	-	+	-
Scaling	+	-	+	+	-	-	-
Calculate the sample	-	+	+	-	-	-	-
Graphical representation of the data	+	+	+	-	+	+	-

tion about new receipts to the archive, comparative materials of surveys of different years and trends in social change.

The Council of European Social Science Data Archives (CESSDA) was established in 1976. It is an informal association of European national data archives of about 70,000 studies in the social sciences and humanities. The main task of this organization is to ensure the functioning of a full-fledged sustainable research infrastructure. This association helps the scientific community to conduct high-quality research in the social sciences to form effective solutions to the main challenges facing society today and to facilitate teaching and learning in social sciences. CESSDA must fulfill its mission by participating in the development and coordination of standards, protocols and the dissemination of best training practices.

The history of national archives began in 1985 when the first large-scale database of sociological research at the Institute of Social Research of the USSR Academy of Sciences was created.

In December 2014, the National Sociological Data Bank “Kyiv Archive”was established at the initiative of the Kyiv International Institute of Sociology and Center “Social Indicators” in cooperation with the Kyiv-Mohyla Academy under a grant from the International Renaissance Foundation (ukraine.survey-archive.com, 2014).

The directory contains a list of sociological research, available for download from the website of the National Bank research (https://ukraine.survey-archive.com). While the website contains only part of the available data, and the archive continues to grow. Registered users have the ability to download survey data directly through the website. Downloadable materials include an array (SPSS / OCA), questionnaires, survey description, description of the methodology, supporting materials.

The monitoring study presented at the Bank in the format of a coherent set of files. The archive search is by keywords, and indexing subjects of research for their name, the name of the author of the study, date collection, and other parameters that characterize research in General. The purpose of the search in this part of the archive is to receive the data file and accompanying documentation for further secondary analysis. Storage unit in the archive is determined by a separate research question.

Nowadays, the number of organizations that transmit information to the National Bank of Sociological Data includes Kyiv International Institute of Sociology, TNS, Institute of Sociology of NASU, Taras Shevchenko National University of Kyiv, Ukrainian Center for Economic and Political Studies named after O. Razumkov, Ilko Kucheriv Democratic Initiatives Foundation, Ukrainian Institute for Social Research named after O. Yaremenko, Kyiv Center for Political Research and Conflict Studies, Center for Social and Marketing Research “SOCIS” (ukraine.survey-archive.com, 2014).

Since the professional activity of sociologists-empiricists is mass, the archives of sociological data as an institutional entity will be used productively in the case of their active cultivation at the level of both individual and collective social practices. Such transnational archives are user-friendly means of solving research problems. They are characterized by mobility, accessibility for understanding, represent a high level of professionalism of scientists, without exaggeration is a more convenient modern form of research not only in sociology but also in related sciences.

The final stage of any empirical sociological study involves the preparation of a final document (information, press release, information note, analytical note, report). Its choice is determined by the type of study and the wishes of the customer. MS Windows applications or alternative services available to the researcher are used to make the report and prepare for the presentation of the research results.

5 RESULTS AND DISCUSSION

As the study of scientific literature and personal practical experience, professional training of specialists-sociologists in higher education, has wide opportunities to use information and communication technologies, without which no full-fledged implementation of empirical sociological research. The variety of information technologies, as well as their capabilities, is impressive. However, we should not forget that the most important component of digital literacy of a sociologist is the formation and development of algorithmic thinking. It is a set of specific ideas, skills and abilities related to the concept of the algorithm, methods of its development, use and recording.Mastering a rich arsenal of application packages of computer programs, cloud technologies for the collection and processing of sociological data is an important component of the training of future sociologists.

Each of the above-mentioned software products has its characteristics of use in applied sociology, primarily related to their functional purpose, compatibility with alternative programs, pricing and technical conditions of use.The modern statistical package must meet the following minimum set of requirements: modularity; use of simple problem-oriented language to formulate user's tasks; automatic organization of data processing; introduction of a data bank and compiling reports on the results of the analysis; dialogue mode of work of the user with a package; compatibility with other software.The developers of most statistical packages often claim that the program they have developed is the best for data processing. Given the variety of proposals, it is difficult to make the right choice in favor of a particular package of applications. However, if a sociologist does not have sufficient knowledge and competencies, then even the most advanced software product will not allow making quality collection and analysis of sociological data. At the same time, an incorrectly selected software package that does not have the proper technical characteristics can slow down the work of even an experienced analyst, making it difficult to identify the necessary patterns and obtain the results of data analysis.

However, it is important to emphasize the fact that in connection with the computerization of companies the new demands put forward in relation to the teaching staff of higher educational institutions, which imparts training to students. Their level of informational knowledge requires a significant increase in that is one of the promising areas of research.

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Research of Teachers' Occupational Health by Means of Digital Technologies

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Keywords: Teachers, Teacher's Health, Occupational Health, Stress Resistance, Pedagogic Consulting, Digital Technologies.

Abstract: The article is devoted to the problem of studying the teachers' state of occupational health and finding ways of its preservation and strengthening under the conditions of quarantine, caused by a coronavirus infection. To study the general state of teachers' occupational health, we used Google Forms questionnaire, which had been developed by the authors of the research. The questionnaire included defining the characteristics of teachers' motivation to engage in healthy activities, the study of the internal picture of occupational health, and their emotional well-being at school before and during the quarantine. The focus of the research was the analysis of the main psychological indicators of occupational health (emotional well-being, occupational stress resistance, satisfaction from teaching), considering the length of working in a school, type of school, gender. The results of the study of teachers' occupational health and its comprehensive analysis served as the basis for determining the content and form of providing them with consulting services. The study presents functions, directions, and the program of the Center of Pedagogical Consulting to preserve and strengthen teachers' occupational health, identify the opportunities to use digital technologies in the implementing of pedagogical consulting under quarantine restrictions, associated with the COVID-19 pandemic.

1 INTRODUCTION

Occupational health of a teacher is an important factor in the success of pedagogical activities, their creative self-realization, and safe constructive interaction in the educational process. The state of health of students also largely depends on the state of teachers' occupational health. Psychogenic maladaptation, didactogenia, psychosomatic disorders of students' health are very often the result of poor occupational teachers' health. And without a proper culture of occupational health, teacher will not be able to form a culture of health of their students. Need to improve the quality of education, reformation of general secondary education, implementation of the concept of the New Ukrainian School, the concept of development of pedagogical education in Ukraine, digitalization of education increase the burden on teachers, at the same time set new tasks for a teacher. New working conditions during distance and blended learning due to a pandemic (Bobyliev and Vihrova, 2021), insufficient skills in organizing distance learning using modern digital technologies add up to this. These problems are stressors that negatively affect teachers, worsen their psychological well-being, and occupational health (Velykodna and Frankova, 2021).

Occupational health of a particular teacher depends on their attitude towards it. It has been proven that teacher's awareness of the value of occupational health ensures the formation of their believes about

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the need to purposefully preserve and strengthen their own health through adherence to the principles of a healthy lifestyle (Meshko and Meshko, 2019). Irresponsible treatment of one's health leads to its deterioration, emotional exhaustion, reduced efficiency and accelerates occupational aging. An important condition for ensuring occupational health of a teacher is a high level of motivation to carry out healthy activities, emotional hardening of the body, prevention of excessive stress (distress). Therefore, teachers must have reasonable strategies for occupational health. Such aspects have not yet been properly reflected in the psychological and pedagogical literature and are insufficiently studied. Today we need to study preventive measures, ways to preserve and strengthen occupational health of teachers and increase the level of their stress resistance. This is especially true at the time when "the world is experiencing an unprecedented global health crisis – COVID-19 is spreading human suffering, destabilizing the global economy and radically changing lives of billions of people around the world" (UN, 2020a). Quarantine measures due to coronavirus infection cause deterioration in the mental health of people, including teachers, increasing the level of their anxiety. If the coronavirus affects the human psyche, the matter is not only in the manifestations of disease but in the atmosphere of anxiety created by the pandemic. To date, there is no accurate official data on the number of people suffering from various types of situational depressive disorders.

According to Bondar (Bondar, 2020), during the pandemic, about 80% of adult Ukrainians suffer from depressive disorders. Therefore, today the attention of world organizations is focused on the mental health of children and adults during the pandemic and the mass forced use of distance learning technologies in the context of ensuring both the right to education and the right to health (UN, 2020b). World Health Organization, together with partners, provides instructions and guidance to people on maintaining mental health during the COVID-19 pandemic.

All this raises the issue of psychological assistance to teachers, preventive and psycho-corrective measures to preserve and strengthen occupational health remotely, support their personal and professional growth. To address the outlined issues, it is important to monitor the state of occupational health of teachers, study the features of their internal picture of occupational health, the requests of teachers in the context of healthy activities. These data and their thorough analysis are necessary to determine the content and form of consulting services, develop a system of training sessions, workshops for personal and professional growth of teachers, increase their stress resistance, master smart strategies for occupational health.

In today's COVID-19 environment, it is important and necessary to use digital technologies that allow both teacher's occupational health to be monitored remotely and to help restore, preserve, and strengthen it. Therefore, the purpose of the study is to examine the state of teachers' occupational health, the features of their internal picture of occupational health by digital technology to determine the content and form of providing them with consulting services.

2 METHODS

In the research, occupational health is interpreted as an integral characteristic of the functional state of the body, the global mental state of the individual, which is characterized by dynamic harmony of internal experiences and related efficiency and success of teaching, the ability to resist negative factors accompanying this activity.

The study is based on the principles of orthobiosis of the individual, which means a person's mental health, a healthy lifestyle. A healthy, intelligent lifestyle is the self-organization of an individual's life on the principles of ecology, optimism, and positive activity (Makarova and Gakh, 2005, p. 93).

In the study, we focused on maintaining and strengthening mental health of a teacher, because it is a system-forming component of health and all its aspects. Mental health reflects the state of the intellectual and emotional sphere of teacher, his general mental comfort and provides an adequate behavioral response. Mental health lays the foundation for its higher-level - psychological health, which is the ability to fully develop, to be the subject of their own lives. Psychological health is associated with resistance to stress, harmony, and spirituality of the individual makes the individual self-sufficient. Its core is the subjectivity of the individual, characterized by an understanding of himself and others, the ability to set life priorities, direct activity responding their own needs and interests, conscious and a responsible attitude to their lives and future.

The study is based on the statements of psychosomatics (Malkina-Pykh, 2005) and psychoenergetics (Boyko, 2008) that by caring about one's mental health, one is concerned about one's physical health, solving psychological problems and getting rid of many physical ailments, achieving emotional well-being, and creating a good mood – and improves physical well-being.

The crucial role in maintaining and strengthening health belongs to the person himself, his way of life, values, attitudes, and subjective attitude to his own health (Batsyleva et al., 2018, p. 39). In scientific literature, the terms "subjective concept of health" and "internal picture of health" are used to characterize the subjective attitude to one's own health. The concept of "perception of health" dominates in the scientific literature.

In the context of our study, the concept of the subjective concept of health is important for a comprehensive description of a person's perception of their health. This concept covers the types of attitudes towards health, assessment of the condition, and efforts aimed at its preservation, strengthening development, and implementation (Savchyn, 2019, p. 190). The attitude to occupational health is manifested in the actions and deeds of teachers, their experiences, and judgments about the factors that affect their physical and psychological well-being. Attitudes towards occupational health can be conscious or unconscious, responsible or irresponsible, adequate or inadequate, value-based. Savchyn (Savchyn, 2019) singles out the following strategies of a person's attitude to his health: 1) the strategy of constant subjective and objective control of the state of health; 2) health strategy; 3) strategy for strengthening and developing health; 4) strategy of timely full-fledged rehabilitation and restoration of health; 5) strategy for implementation, use and testing of health; 6) strategy of pathological attitude to health (Savchyn, 2019, pp. 144-145). These strategies concern not only general health of a person, its individual components, but also occupational health.

In health psychology, the internal picture of health is interpreted as a special attitude of an individual to their health, which is expressed in the awareness of its value and active-positive efforts to improve it (Nikiforov, 2006, p. 437). Ananyev (Ananyev, 1998) defined the internal picture of occupational health as self-awareness and self-knowledge of a person himself/herself in terms of health. The internal picture of occupational health reflects the individual's perception of health in general and their own health in particular. These concepts are interrelated.

An effective way to protect against occupational stress is to increase the level of occupational stress resistance of teachers, which determines the ability to withstand stress, negative factors of pedagogical activities, stressful situations, overcome occupational difficulties without harm to health and activities, find their own resources in difficult conditions (Meshko and Meshko, 2019, p. 60). Increasing the level of occupational stress resistance of a teacher is associated with the search for resources that help them overcome the negative effects of stressful situations. The effectiveness of counteracting occupational stress is determined by several personal characteristics, among them a decisive role belongs to the motivational sphere of teaching. From the perspective of our study, it is important to say that active coping with stressful situations in combination with the positive use of social contacts increases the stress resistance of a teacher (Nikiforov, 2006, p. 231). Increasing the stress resistance of teachers contributes to mastering the skills of constructive conflict resolution; formation of stress protection strategy; learning methods and techniques of self-regulation; formation of sanogenic thinking.

One of the main conditions for the formation of psychological stability is autopsychological competence, which is manifested in high mobilization, readiness, and ability to maximize volitional stress, the ability to actively suppress negative emotions, maintain self-control and endurance in any situation (Stepnova, 2017, p. 117). Autopsychological competence is a personal neoplasm that triggers the mechanisms of self-regulation, self-control, etc. The development of autopsychological competence makes it possible to actively influence functional states and thus increase the ability to withstand stress and improve performance. Therefore, a necessary prerequisite for maintaining and strengthening occupational health is the development of the autopsychological competence of a teacher, the focus on self-development, personal and professional growth. These occupational health provisions became the substantive basis for the study.

The Digital Competence Framework for Educators (DigCompEdu), which covers 22 digital competencies, served as a methodological guideline for organizing and conducting research using digital technologies (Brolpito, 2018). These competencies are the basis for the organization of distance education with distance learning technologies. Besides, in the study, we relied on the guidelines of the Ministry of Education and Science of Ukraine on the organization of distance learning and the use of digital technologies in educational institutions (thedigital.gov.ua, 2020; mon-covid19.info, 2020; Vuorikari et al., 2016), took into account international experience on this issue in the EU (www.osvita.org.ua, 2020).

The analysis of normative documents (MON, 2021, 2013; Sakalo, 2020; uiite.kpi.ua, 2000) gives grounds to claim that digital technologies of distance education can be used to improve the skills of teachers, provide them with educational services and psychological support. These technologies are already in use both in the European and Ukrainian universities to provide psychological support to teachers and improve their skills in the application of these technologies in distance education. There is also the practice of using team building by teachers, school counselors, social workers, psychologists to improve the well-being of students through socio-emotional learning (SEL), which is possible through the training of teams of specialists in schools, counseling and special events for them (Balch et al., 2021).

As far as the main psychological indicators of teachers' occupational health are emotional well-being, occupational stress resistance, and satisfaction with teaching, they have been the focus of our research. The research used a questionnaire developed by us to study general state of occupational health of teachers, as well as observations and conversations with teachers (novpoltava, 2020). The survey revealed the degree of awareness of teachers' occupational health, the depth, and characteristics of their motivation to carry out health activities, the study of the internal picture of occupational health, as well as the state of their emotional well-being at school. The survey was conducted using a questionnaire via Google Forms. Teachers from Ternopil, Poltava and Kharkiv regions (Ukraine) took part in the survey anonymously and voluntarily.

The questionnaire, developed by us, contains 12 questions, which provides answers to each of them in two aspects – before quarantine and during the quarantine. The first question is aimed at teachers' self-assessment of their general health; the second is to identify the peculiarities of the attitude to one's health; third, finding out how educators address health issues. The second block of the questionnaire covers 4 questions, which are aimed at identifying the following aspects: 1) what emotional state (mood) prevails among teachers at school; 2) whether they feel psycho-emotional stress at school; 3) how easy it is for them to control their emotions, to control themselves in situations of professional interaction, including during distance learning; 4) whether teachers have techniques for relieving emotional stress. The following block of questions of the questionnaire is aimed at finding out: 1) whether teachers have the opportunity to receive timely psychological assistance in solving their personal problems; 2) whether the state of their health affects the productivity of professional activity; 3) whether they are satisfied with their professional activity; 4) whether teachers need psychological help to maintain and strengthen occupational health. This section of the questionnaire provides questions for tracking the relationship between teachers' well-being and distance learning, identifying the impact of the use of digital technology on the psychological well-being and occupational health of teachers.

The survey let us make the identification of gender differences in occupational health of teachers, differences in the health of teachers with different lengths of service, as well as teachers of rural and urban schools, which is also important for determining the content of consulting services, the content of correctional and preventive programs under the conditions of activity of the Center of pedagogical consulting, and under the conditions of quarantine.

3 RESULTS

322 teachers took part in the survey, in particular, 202 teachers (62.7%) of urban schools and 120 (37.3%) of rural schools. 90% of respondents are women, 10% are men. Experience of 20 surveyed teachers (6.2%) up to 3 years; 52 (16.2%) – from 3 to 10 years; 114 (35.4%) – 10–20 years; the rest – 136 (42.2%) have been working at school for more than 20 years.

The results of the study allow us to characterize general state of teachers' occupational health. We determine some indicators of teachers' health. It is possible to trace the attitudes of teachers to their health and to analyze the dynamics of basic psychological indicators of teachers' occupational health (emotional well-being, occupational stress, occupational satisfaction), taking into account gender, type of school, and work experience.

When answering the first question of the questionnaire "Assess general state of your health", the majority of teachers (50.7%) chose the answer "good". The "excellent" option was chosen by 25.4% of respondents; 18.3% of teachers chose the "satisfactory" option; 5.6% of teachers rated their health as unsatisfactory. Teachers assessed their health during the quarantine in a slightly different way. The number of teachers who assessed their health as satisfactory increased 2.5 times (to 45.6%). Quarantine has greatly influenced teachers' assessment of their own health. This can be explained both by the influence of distance learning and by increasing the level of anxiety during the quarantine, the disease of some teachers on COVID-19. Researchers have found that COVID-19 can affect patients' mental health. Patients who have relapsed with COVID-19 are more likely to suffer from a post-traumatic stress disorder and obsessive-compulsive disorder. In addition, patients with coronavirus are more likely to experience symptoms such as anxiety and insomnia (new-s.com.ua, 2020; NAMSU, 2020). A comparative analysis of the indicators of the state of occupational teachers' health in urban and rural schools revealed differences in their assessment of their own health (figure 1, 2).

In particular, teachers of rural schools rated their health before the quarantine higher (the option "excellent" and "good" was recorded in 81.3% of responses. For teachers of urban schools, this percentage is 73.1%. During the quarantine, these figures decreased by 23% of teachers in rural schools and 28.3% – in urban schools.

The quarantine has made more changes in women's teachers' assessment of their own health. In particular, the number of female teachers who rated their health as "excellent" decreased by 17.5%, and the number of women who rated their health as "good" decreased by 9.5%. It is worth pointing that a significant part of male teachers assessed their health as "unsatisfactory" (18.8% before the quarantine and 16.7% during the quarantine), and as "satisfactory" (12.5% before the quarantine and 41.7% after the quarantine).

The study revealed differences in the health status of teachers with different teaching experience. It has been found that the longer the teaching experience, the worse occupational health of teachers. In particular, the deterioration of health indicators is observed in those whose work experience in school exceeds 10 years, a sharp deterioration – after 20 years of schoolwork. A negative state of quarantine was recorded in 10.2% of teachers with more than 20 years of experience.

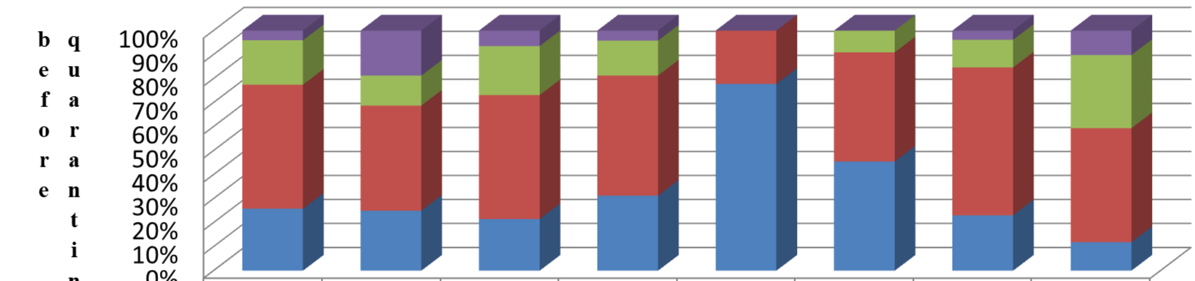
Teachers' answers to the second question of the questionnaire "How do you feel about your health?" allowed us to determine trends in the change of teachers' attitudes to their health during the quarantine.

The percentage of teachers who chose the answer "my health worries me on a case-by-case basis (illness, preventive examination, medical commission, etc.)" has tripled. The number of educators who are concerned about their health even when they are feeling well has increased. During the quarantine, significantly more respondents (49.7%) (before the quarantine – 35.4%) strive to maintain their own health at the appropriate level. This indicates both greater attention to their health and increased levels of anxiety during the pandemic, which only forced teachers to pay attention to their health. A prolonged pandemic can help shape the need and develop the habit of taking care of their health under any circumstances.

To identify the specifics of healthy activities, the questionnaire provides the question "How do you solve your health problems?". The results of the survey show that before the quarantine, 32.9% of teachers solved their health problems on their own, and 61.5% of respondents sought medical help. During quarantine, the number of respondents seeking medical help increased to 87.1%. They are driven by fear of coronavirus infection, the severity of the disease, and the complexity of its treatment, the possibility of health complications.

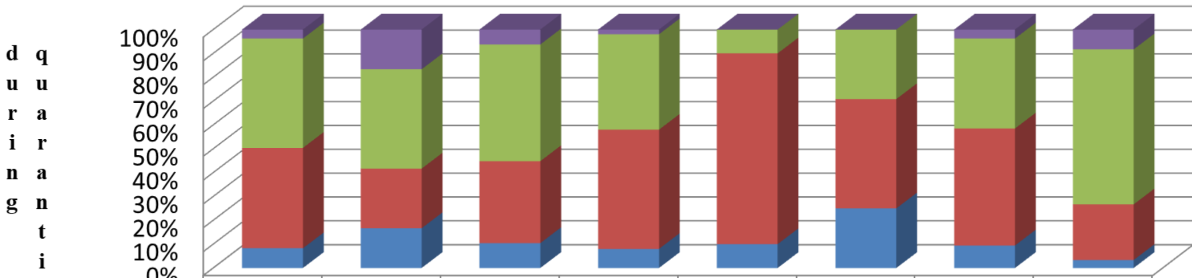
The results of the study give grounds to state the strengthening of negative trends in the psychological well-being of teachers during the quarantine. Respondents' answers to the questionnaire "What emotional state (mood) prevails in school?" (figure 3, 4).

Before the quarantine, only 4.5% of school teachers had an unstable, often negative mood. Respondents with a depressive, negative attitude to the quarantine were not identified, while 6.7% of surveyed teachers during the quarantine at school are dominated by a negative, depressive state. It is worth noting that 24% of teachers believe that during the quarantine they are in school with a predominance of unstable, often negative mood. The number of teachers who assessed their mood as stable, positive, and energetic significantly decreased (from 66.2% to 21.8%) during the quarantine. Before the quarantine, both urban and rural school teachers were dominated by a positive mood (the total response rate was "stable, positive, vigorous" and "unstable, often positive" – 95.2% and 95.5%, respectively). Somewhat different results were found during quarantine: the depressive, negative mood was found in 31.1% of urban teachers and 30.1% of rural school teachers. The use of digital technologies has a more negative effect on the well-being of most teachers in rural schools, both in the quarantine and after it. During the quarantine, psychological well-being deteriorated significantly for teachers of all ages, the largest share among teachers with up to three years of experience (10% are in a negatively depressive state, 20% – in an unstable, often negative state) and with more than 20 years of experience (6% are in a negative, depressive state, 33.3% – unstable, often negative state). During the quarantine, negative tendencies in the emotional state of both male and female teachers intensify. Therefore, prevention of negative attitudes and special work on psychological support of teachers is needed. In this context, the presence in Ukraine of the community "Psychological Support", which arose during the pandemic and operates in the Viber messenger within the "Coronavirus_info". But today, this practice of support, as our study shows, is not enough for teachers as representatives of a very stressful profession. Teachers note the presence of disorders in their own emotional sphere (tension, difficulties in managing their emotions). Previously acquired knowledge and skills of self-regulation of emotional states



	women	men	urban schools	rural schools	experience up to 3 years	experience from 3 to 10 years	experience of 10-20 years	experience more than 20 years
unsatisfactorily	4,03%	18,75%	6,45%	4,17%	0,00%	0,00%	3,85%	10,17%
satisfactorily	18,55%	12,50%	20,43%	14,58%	0,00%	9,09%	11,54%	30,51%
good	51,61%	43,75%	51,61%	50,00%	22,22%	45,45%	61,54%	47,46%
perfectly	25,81%	25,00%	21,51%	31,25%	77,78%	45,45%	23,08%	11,86%

Figure 1: The indicators of the state of occupational teachers’ health before quarantine.



	women	men	urban schools	rural schools	experience up to 3 years	experience from 3 to 10 years	experience of 10-20 years	experience more than 20 years
unsatisfactorily	3,76%	16,67%	6,25%	2,00%	0,00%	0,00%	3,77%	8,33%
satisfactorily	45,86%	41,67%	48,96%	40,00%	10,00%	29,17%	37,74%	65,00%
good	42,11%	25,00%	34,38%	50,00%	80,00%	45,83%	49,06%	23,33%
perfectly	8,27%	16,67%	10,42%	8,00%	10,00%	25,00%	9,43%	3,33%

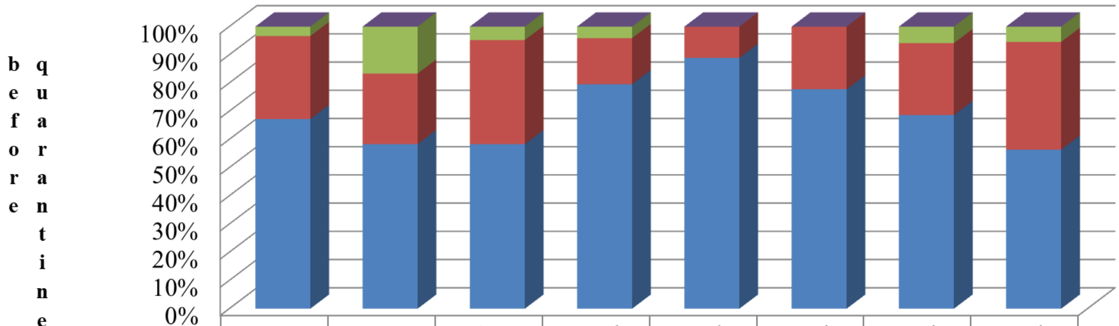
Figure 2: The indicators of the state of occupational teachers’ health during quarantine.

in the current pandemic was not enough. So, psycho-emotional stress from work at school before the quarantine (5.8% of respondents chose the answer “yes”; more than tripled (up to 18.6%) the number of such teachers during quarantine). The number of respondents (from 21.2% before the quarantine to 46.9% during the quarantine) who chose the answer “rather “yes” than “no” to the questionnaire “Do you feel psycho-emotional stress from working in school?”.

Teachers also noted problems in managing their emotions, self-regulation in the situations of professional interaction, in particular, during distance learning. The number of respondents significantly increased (by 34.2%), who answered the questionnaire “How easy is it for you to control your emotions in situations of professional interaction, including during distance learning?” chose the answer “I encounter some difficulties” in managing emotions, self-control; the number of those who chose the answer “difficult, I encounter significant difficulties” increased by 8%.

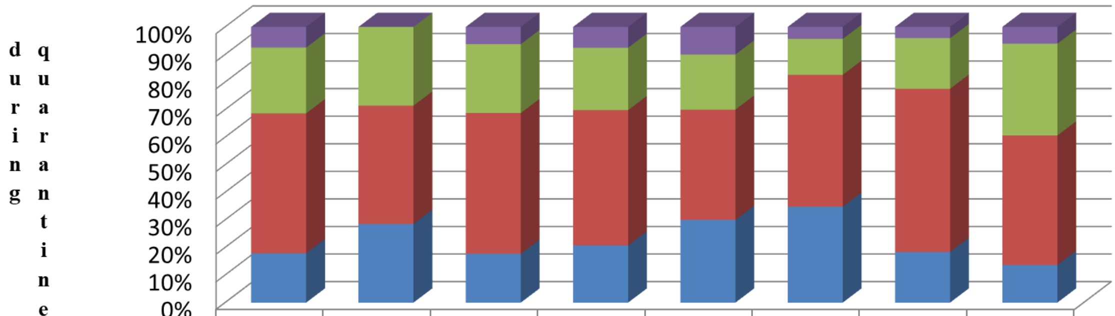
In the context of providing counseling help, determining the content of consulting services, teachers’ answers to the questionnaire “Do you know how to relieve emotional stress?” (figure 5, 6).

During the quarantine, the total number of teachers who gave an affirmative answer to this question decreased from 34.5% to 13.3%. During the quarantine, the indicators of rural school teachers deterio-



	women	men	urban schools	rural schools	experience up to 3 years	experience from 3 to 10 years	experience of 10-20 years	experience more than 20 years
negative, depressive state	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%
unstable, often negative	3,36%	16,67%	4,76%	4,08%	0,00%	0,00%	5,88%	5,45%
unstable, often positive	29,41%	25,00%	36,90%	16,33%	11,11%	22,22%	25,49%	38,18%
stable, positive, vigorous	67,23%	58,33%	58,33%	79,59%	88,89%	77,78%	68,63%	56,36%

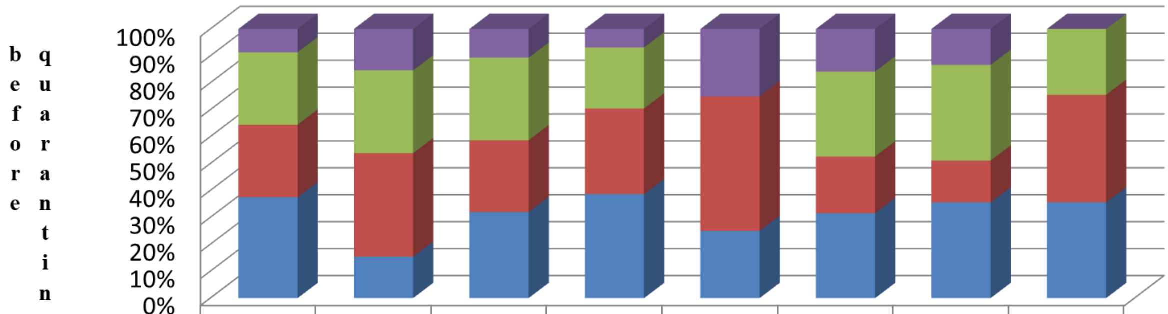
Figure 3: Respondents' answers to the questionnaire "What emotional state (mood) prevails in school?" before quarantine.



	women	men	urban schools	rural schools	experience up to 3 years	experience from 3 to 10 years	experience of 10-20 years	experience more than 20 years
negative, depressive state	7,46%	0,00%	6,25%	7,55%	10,00%	4,35%	4,08%	6,06%
unstable, often negative	23,88%	28,57%	25,00%	22,64%	20,00%	13,04%	18,37%	33,33%
unstable, often positive	50,75%	42,86%	51,04%	49,06%	40,00%	47,83%	59,18%	46,97%
stable, positive, vigorous	17,91%	28,57%	17,71%	20,75%	30,00%	34,78%	18,37%	13,64%

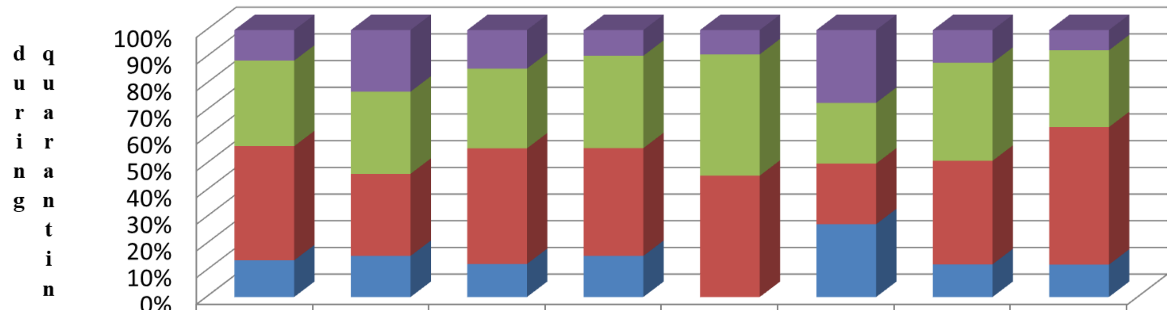
Figure 4: Respondents' answers to the questionnaire "What emotional state (mood) prevails in school?" during quarantine.

rated even more (from 44.2% to 29.5% the number of respondents decreased, who have techniques for self-regulation of emotional state). The answers of female and male teachers to this question can be interpreted ambiguously: during the quarantine, the number of female teachers who have techniques for relieving emotional stress has significantly decreased (from 37.5% to 13.7%). Both before the quarantine and during the quarantine, we recorded the same number of male teachers who have techniques for relieving emotional stress, (15.38%). The share of such teachers, who chose the answer "yes" rather than "no" during quarantine, decreased by 8%). Before the quarantine, every fourth teacher with up to three years of working experience did not have the techniques to relieve emotional stress. During the quarantine, the most problems in mastering the techniques of self-regulation were found with teachers who have up to ten years of experience – such as 27.3%. 45.5% of teachers chose the answer "no" sooner than "yes" with work experience of up to three years experience, 36.7% – work experience of 10–20 years, 28.8% – work experience of over 20 years. Increasing emotional stress during a pandemic is caused not only by the coron-



	women	men	urban schools	rural schools	experience up to 3 years	experience from 3 to 10 years	experience of 10-20 years	experience more than 20 years
no	8,65%	15,38%	10,67%	6,82%	25,00%	15,79%	13,33%	0,00%
rather no than yes	26,92%	30,77%	30,67%	22,73%	0,00%	31,58%	35,56%	24,44%
rather yes than no	26,92%	38,46%	26,67%	31,82%	50,00%	21,05%	15,56%	40,00%
yes	37,50%	15,38%	32,00%	38,64%	25,00%	31,58%	35,56%	35,56%

Figure 5: Respondents' answers to the questionnaire "Do you know how to relieve emotional stress?".



	women	men	urban schools	rural schools	experience up to 3 years	experience from 3 to 10 years	experience of 10-20 years	experience more than 20 years
no	11,45%	23,08%	14,43%	9,62%	9,09%	27,27%	12,24%	7,58%
rather no than yes	32,06%	30,77%	29,90%	34,62%	45,45%	22,73%	36,73%	28,79%
rather yes than no	42,75%	30,77%	43,30%	40,38%	45,45%	22,73%	38,78%	51,52%
yes	13,74%	15,38%	12,37%	15,38%	0,00%	27,27%	12,24%	12,12%

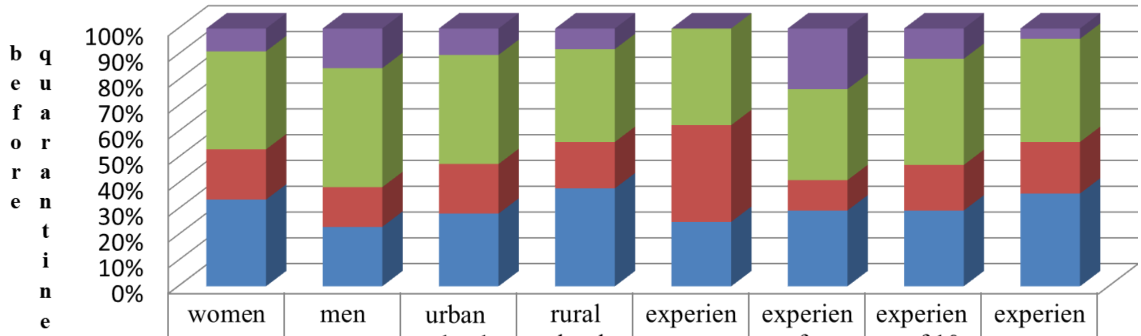
Figure 6: Respondents' answers to the questionnaire "Do you know how to relieve emotional stress?" during quarantine.

avirus pandemic, but also by the new working conditions of teachers in the distance and blended learning, the need to master digital technologies in a short time, and unwillingness to act in changed conditions.

Not all teachers have the opportunity to receive timely psychological assistance (figure 7, 8).

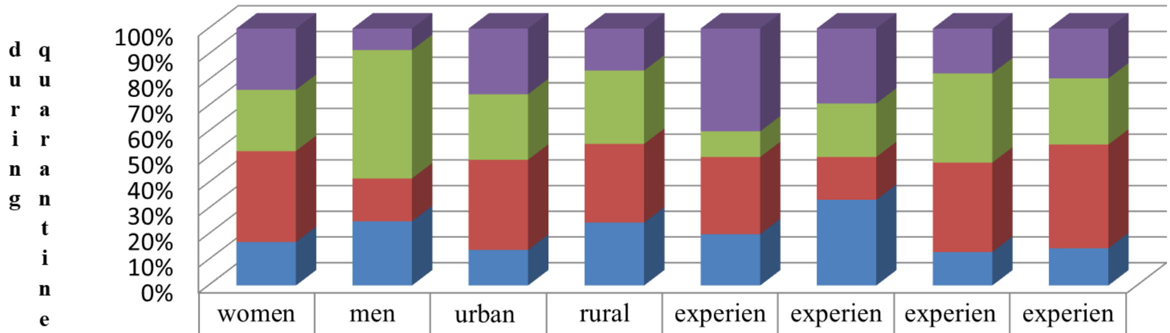
Answering the question of the questionnaire "Do you have the opportunity to receive timely psychological assistance in solving personal and professional problems?", 9.4% of teachers chose the option "no", and 39.8% – "rather no than yes".

During the quarantine, the emphasis shifted somewhat: the number of respondents who have the opportunity to receive psychological assistance decreased. Interestingly, teachers of urban (52.5%) and rural schools (44%) both before quarantine and during the quarantine are not able to receive psychological assistance in solving personal and professional problems. The explanation for this is: many teachers of rural schools are looking for other ways to solve personal and professional problems, more stress-resistant, they have formed a position of "self-psychotherapist". This was evidenced by the results of interviews with teachers and the observation of their professional ac-



	women	men	urban schools	rural schools	experience up to 3 years	experience from 3 to 10 years	experience of 10-20 years	experience more than 20 years
no	8,85%	15,38%	10,26%	8,00%	0,00%	23,53%	11,76%	4,00%
rather no than yes	38,05%	46,15%	42,31%	36,00%	37,50%	35,29%	41,18%	40,00%
rather yes than no	19,47%	15,38%	19,23%	18,00%	37,50%	11,76%	17,65%	20,00%
yes	33,63%	23,08%	28,21%	38,00%	25,00%	29,41%	29,41%	36,00%

Figure 7: Respondents' answers to the questionnaire "Do you have the opportunity to receive timely psychological assistance?" before quarantine.



	women	men	urban schools	rural schools	experience up to 3 years	experience from 3 to 10 years	experience of 10-20 years	experience more than 20 years
no	23,85%	8,33%	25,53%	16,33%	40,00%	29,17%	17,39%	19,35%
rather no than yes	23,85%	50,00%	25,53%	28,57%	10,00%	20,83%	34,78%	25,81%
rather yes than no	35,38%	16,67%	35,11%	30,61%	30,00%	16,67%	34,78%	40,32%
yes	16,92%	25,00%	13,83%	24,49%	20,00%	33,33%	13,04%	14,52%

Figure 8: Respondents' answers to the questionnaire "Do you have the opportunity to receive timely psychological assistance?" during quarantine.

tivities. The presented results will encourage the shift of emphasis in consulting activities, the definition of its new facets (aspects). During the quarantine, more psychological help is needed, but female teachers are not able to receive it (their number increased from 8.9% to 23.9%). The same applies to teachers whose school experience is from 3 to 10 years (23.5% of respondents). Among the surveyed teachers who work at school for up to three years, there are no those who are not able to receive the quarantine for psychological assistance; during the quarantine, their share increased to 40%. This indicates an increasing need for psychological help and professional counseling.The school psychological service does not pay enough attention to maintaining and strengthening the professional health of teachers. Its focus is on working with students and their psychological support in the educational process. A special center for professional psychological and pedagogical support for teachers is needed.

Analysis of the answers to the following question of the questionnaire "Does the use of digital technologies in the learning process affect your psychological well-being and health" revealed the following: during the quarantine, the number of teachers increased (from 19.5% to 49.3%) almost three times who estimate their psychological well-being more negatively than positively affected by the use of digital technologies in the learning process. Both before and after the quarantine, the use of digital technologies has a more negative effect on the well-being of rural school teachers. This is because of the unwillingness of many teachers to distance and blended learning, the uncertainty of requirements, low digital competence of some teachers, lack of access to quality Internet. In this context, the course, "Effective Google solutions for Education for cloud interaction", developed by Google Ukraine with the support of the Ministry of Education and Science of Ukraine for teachers of general secondary education, is relevant (MON, 2020; Academy of Digital Development, 2020).

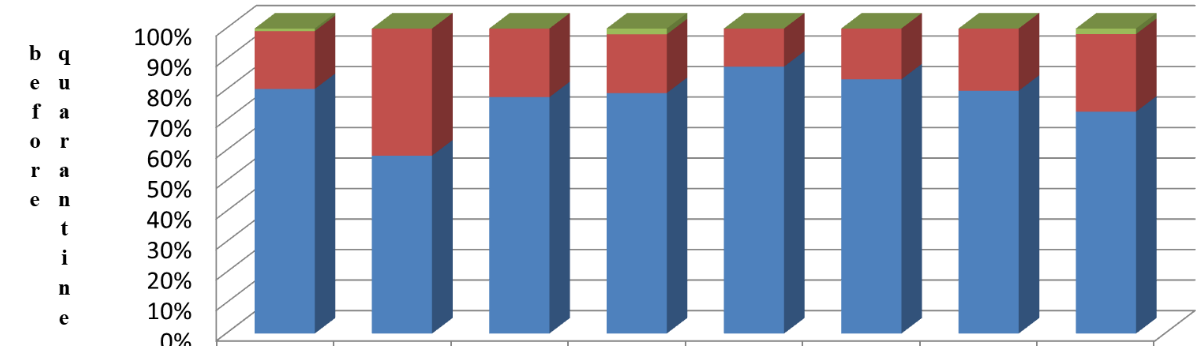
The state of health, according to many teachers, hinders their productive professional activity: the answer "yes" was chosen by 13.4% of teachers; "rather "yes" than "no" – 17.5%; "Rather "no" than "yes" – 32.5%); "no" – 36.5%). During the quarantine, these indicators did not change for the better, in particular, the number of teachers whose health hinders productive professional activity increased by 2.2%; by 14.2% – the number of respondents whose health mostly hinders productive teaching (answer option "rather yes, than no"). This means that the limitations of quarantine and the new burdens caused by it affect the way of life that previously allowed teachers to work productively. Lack of training, closure of fitness clubs, restrictions on health and recreation, the prohibition of mass events, sports events, lack of new positive experiences, etc. affect the health of teachers, their satisfaction with their professional activities. We need a new model of life during a pandemic, which would help us learn the new rules of a healthy (smart) lifestyle.

The results of teachers' answers to the questionnaire "Are you satisfied with your professional activity?" are extremely important (figure 9, 10).

During the quarantine, the number of respondents satisfied with their professional activities decreased from 78% to 26.4%; the number of those who are partially satisfied increased from 21.2% to 68.1%, and those who were dissatisfied with professional activity – from 0.8% to 5.6%. Those who are dissatisfied with professional activities and partially dissatisfied with pedagogical activities in this category were not identified for the quarantine among teachers of urban schools – 22.5%. Among rural school teachers, – 1.9% were dissatisfied with their professional activities, and 19.2% – chose the "partially satisfied" answer. During the quarantine, the number of rural teachers increased almost fourfold, and the number of urban school teachers who were completely or partially dissatisfied with their professional activities tripled. This situation can be explained by the uncertainty and complexity of a teacher in the quarantine, unwillingness to use digital technology in the educational process, and distance and blended learning. It is worth noting that the number of dissatisfied with professional activities to the quarantine was found much higher among male teachers than among female teachers, namely: 41.7% chose the option "partially dissatisfied" with quarantine, and during the quarantine from 0% to 15.4% increased the number of male teachers who are dissatisfied with the teaching. During the quarantine, the number of female teachers who are dissatisfied or partially dissatisfied with their professional activities increased (a total of 74.5%). Negative tendencies in the satisfaction with professional activity of teachers of different age categories during the quarantine are revealed: before the quarantine, teachers who are dissatisfied with pedagogical activity are not revealed; after the quarantine, their share is – 10% (work experience up to 3 years), 50% (work experience – 3–10 years), 31.1% (work experience – 10–20 years), 17.5% (work experience – more than 20 years).

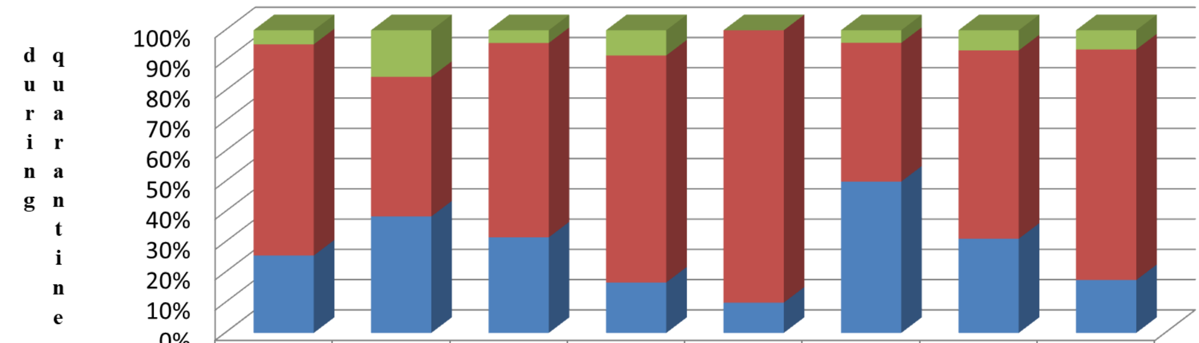
During the quarantine, the number of teachers who need psychological help in terms of maintaining and strengthening occupational health has increased (figure 11, 12).

The answer "yes" before the quarantine was chosen by 3.1%, after the quarantine - 11.2% of respondents, the answer "yes" or "no" before the quarantine was chosen by 12.2% after the quarantine – 28.7% of respondents. Before the quarantine, 12.8% of female teachers and 21.4% of the male teachers needed assistance in terms of healthcare. Somewhat different indicators were found during quarantine: 42% of female teachers and 25% of male teachers need such psychological help. A significant percentage of teachers with different teaching experience who gave an affirmative answer to the question of the need for psychological assistance in maintaining occupational health: 50% (work experience up to 3 years), 38% (work experience from 3 to 10 years), 26.6% (work experience from 10 to 20 years), 46% (work experience more than 20 years). It is much more difficult for rural teachers to get direct, immediate psychological help, digital technologies can be useful here. In this perspective, a large field of activity of the Center of Pedagogical Consulting, whose activities should be aimed at identifying teachers' occupational health problems



	women	men	urban schools	rural schools	experience up to 3 years	experience from 3 to 10 years	experience of 10-20 years	experience more than 20 years
no	0,86%	0,00%	0,00%	1,92%	0,00%	0,00%	0,00%	1,82%
partially satisfied	18,97%	41,67%	22,50%	19,23%	12,50%	16,67%	20,41%	25,45%
yes	80,17%	58,33%	77,50%	78,85%	87,50%	83,33%	79,59%	72,73%

Figure 9: Respondents' answers to the questionnaire "Are you satisfied with your professional activity?" before quarantine.



	women	men	urban schools	rural schools	experience up to 3 years	experience from 3 to 10 years	experience of 10-20 years	experience more than 20 years
no	4,65%	15,38%	4,21%	8,33%	0,00%	4,17%	6,67%	6,35%
partially satisfied	69,77%	46,15%	64,21%	75,00%	90,00%	45,83%	62,22%	76,19%
yes	25,58%	38,46%	31,58%	16,67%	10,00%	50,00%	31,11%	17,46%

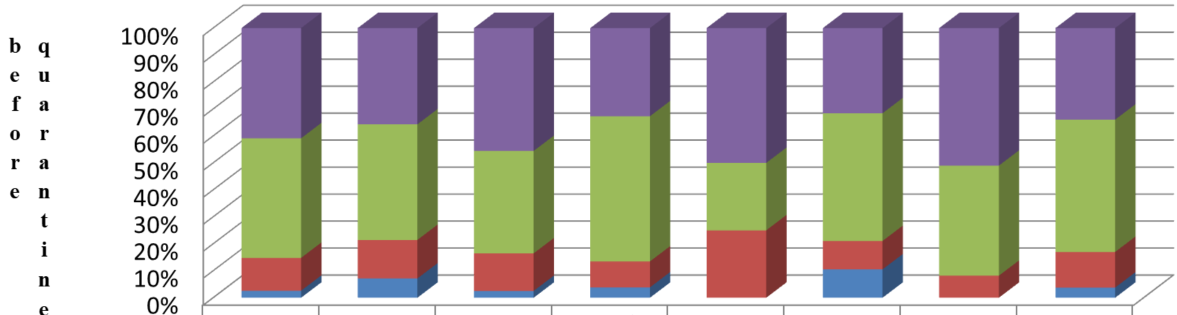
Figure 10: Respondents' answers to the questionnaire "Are you satisfied with your professional activity?" during quarantine.

and helping to address them.

4 DISCUSSION

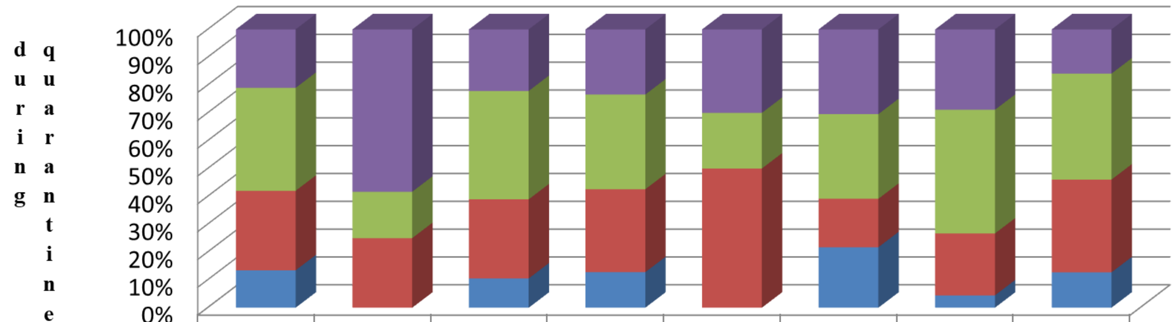
The results of the study show low occupational health of teachers, high levels of emotional stress, the depressing feeling of uncertainty during the pandemic, distance and blended learning, insufficient motivation for healthy activities, low level of self-regulation of emotional states, increased need for psychological help in maintaining and strengthening occupational health, combating occupational stress and emotional exhaustion.

The analysis of the results of the study made it possible to identify differences in the state of occupational health of teachers with different teaching experience. It has been found that the longer the teaching experience, the worse occupational health of teachers. In particular, the deterioration of health indicators is observed in those whose work experience in school exceeds 10 years, a sharp deterioration – after 20 years of schoolwork. Similar data are presented in some foreign publications on this issue. Thus, a study by Pecherkina and Muslumov (Pecherkina



	women	men	urban schools	rural schools	experience up to 3 years	experience from 3 to 10 years	experience of 10-20 years	experience more than 20 years
no	40,87%	35,71%	45,57%	32,69%	50,00%	31,58%	51,02%	33,96%
rather no than yes	44,35%	42,86%	37,97%	53,85%	25,00%	47,37%	40,82%	49,06%
rather yes than no	12,17%	14,29%	13,92%	9,62%	25,00%	10,53%	8,16%	13,21%
yes	2,61%	7,14%	2,53%	3,85%	0,00%	10,53%	0,00%	3,77%

Figure 11: Respondents' answers to the questionnaire " Do you need psychological help to maintain and maintain your professional health?" before quarantine.



	women	men	urban schools	rural schools	experience up to 3 years	experience from 3 to 10 years	experience of 10-20 years	experience more than 20 years
no	21,01%	58,33%	22,11%	23,40%	30,00%	30,43%	28,89%	15,87%
rather no than yes	36,97%	16,67%	38,95%	34,04%	20,00%	30,43%	44,44%	38,10%
rather yes than no	28,57%	25,00%	28,42%	29,79%	50,00%	17,39%	22,22%	33,33%
yes	13,45%	0,00%	10,53%	12,77%	0,00%	21,74%	4,44%	12,70%

Figure 12: Respondents' answers to the questionnaire "Do you need psychological help to maintain and maintain your professional health?" during quarantine.

and Muslumov, 2018), which was published before the pandemic in 2018, shows that the state of professional health of teachers depends on the stages of their professional development (experience). The authors conclude that the expression of indicators in the process of professional development of motivational, emotional, and reflective components of professional health of teachers changes. It is characterized by increased motivation to succeed, acute anxiety, increased rigidity, the development of systemic reflection. We should emphasize that in the course of our study it was found that during the pandemic, anxiety increases regardless of the stage of professional development. Surveys of teachers in the EU confirm that teachers' occupational development is connected to their efforts to maintain occupational health if their health values coincide with their own ones and respond to the school's mission, current identity, and teachers' practice (Jourdan et al., 2016).

A comparative analysis of the indicators of the state of occupational health of teachers in urban and rural schools shows differences in their assessment of their own health, deterioration of emotional state during the quarantine, self-control in professional interaction, satisfaction with professional activities.

The analysis of the answers to the questionnaire revealed gender differences in occupational health indicators of male and female teachers. The results of the survey showed differences in the ability of female teachers and male teachers to self-regulate, mastery of techniques to relieve emotional stress, satisfaction with teaching. The analysis suggests that there is no need to develop separate psychoprophylactic and correctional programs in the coordinates of occupational health separately for female and male teachers. Women's occupational health should focus more on teaching them emotional self-regulation skills. In working with men, more attention should be paid to the formation of motives for personal and professional self-improvement.

Therefore, it is extremely important to identify additional aspects of ensuring occupational health of teachers in the coordinates of the Center of Pedagogical Consulting, which is a new structure in the system of pedagogical education. The Center can work in person and remotely, with the help of digital technologies, which will allow each teacher to use the Center and its resources at a time convenient for them. For this purpose, the university website, YouTube channel, messenger communities, teacher questionnaires in Google forms, groups on social networks, telephone counseling, blogs of the Center's employees can be used.

Based on the analysis of the results of the study, the strategic objectives of the Center of Pedagogical Consulting to preserve and strengthen occupational health of teachers: increase the level of professional stress resistance, the development of mental self-regulation skills; mastering constructive coping strategies, technologies of self-rehabilitation, psychotechnologies of self-healing. Efforts should be made to shape teacher's subjective position as the bearer of a reasonable lifestyle.

Activities to preserve and strengthen occupational health of teachers should be aimed at: increasing the interest of teachers in occupational health as a professional and personal value and ways to ensure it; mastering the methods of implementing health-preserving techniques; self-knowledge and self-development of teachers; activity and creativity of teachers in search and creation of their own systems of improvement, their own experience of maintenance of an optimum condition of occupational health; assisting teachers in overcoming obstacles to a sensible lifestyle. Important aspects of work in this aspect are the prevention of occupational stress, correction of chronic stress of occupational origin, prevention of emotional burnout. It is also necessary to form such a quality of teacher's personality as resilience, i.e. the ability to maintain stability under the influence of external and internal threats, without losing the pace of development to overcome the prevention of destructive behavior, quality of life, and professional activity (Fletcher and Sarkar, 2013).

The results of the analysis of aspects of the responsible attitude of teachers to their health, features of the internal picture of their occupational health served as a basis for determining areas of preventive and psychocorrectional work with teachers, for the content of training practices to form reasonable strategies for occupational health, harmonization of a teacher in the coordinates of the Center of Pedagogical Consulting, which operates at the Ternopil Vladimir Hnatiuk National Pedagogical University (TNPU, 2020c,a,b).

The activities of the Center of Pedagogical Consulting give support for teachers in the educational process and provide them with advice on solving problems related to educational and cognitive activities of students and their personal and professional development (Borova et al., 2019). The mission of the Center is to promote the personal and professional growth of teaching and managing staff.

The Center of Pedagogical Consulting provides educational consulting services (informational, scientific-methodical, instructive-methodical, diagnostic, expert-consultative) in the following areas: professional development of pedagogical workers, implementation of professional development programs, the introduction of innovations in pedagogical activity, implementation of pedagogical projects, experimental work in educational institutions, psychological and pedagogical support of students in the educational process, the formation of the individual educational trajectory of students, the formation of the psychologically safe educational environment, the introduction of health technologies in educational institutions, preservation and strengthening of occupational health of teachers, organization of inclusive education, etc.

The Center of Pedagogical Consulting directs its activities to:

- the study of problems of the educational environment that need to be solved (consulting) and the provision of services;
- carrying out constant information and advertising activities to inform the heads of educational institutions and teachers about the possibility of re-

ceiving consulting services;

- organization and holding of pieces of training, master classes, seminars, round tables under the needs of teachers both within the Center and directly in educational institutions;
- organization of individual and group consultations for management and pedagogical staff;
- organization of corporate training of teachers on the stated topic;
- creating opportunities and providing appropriate services for the development of psychological and pedagogical competence of students-future teachers and future managers-heads of educational institutions;
- researching to improve the quality of training of future teachers and managers for innovative activities in educational institutions.

The program of activities of the Center of Pedagogical Consulting for the preservation and strengthening of teachers' occupational health provides areas of activity, each of which covers a set of activities – specific forms of work that will help to achieve the desired result. This is counseling; use of psychological diagnostic techniques and tests; psychological correction; coaching; seminars, webinars, anti-burnout pieces of training, anti-stress pieces of training, social and psychological actions and initiatives within the activity of LLC "Academy of Innovative Development of Education" (scientific and pedagogical project under the program of joint activities of Ministry of Education and Science of Ukraine and National Academy of Educational Sciences of Ukraine (Academy of innovative education development, 2020b,c,a); mastering the technology of stress management, methods of self-regulation, etc.

We have a matrix of developed activities that can be offered to teachers. In our activity we are guided by the principle: "we have developed, we know – we carry it out for you". The guiding postulate for the Center of Pedagogical Consulting is: we carry out what is in demand, what is relevant, necessary, "hurts" teachers. In our previous publications (Meshko et al., 2020; Meshko, 2016) the pieces of training developed by us, their semantic and procedural filling, influence on an increase of the level of stress resistance, harmonization of teacher's personality are presented.

The Center of Pedagogical Consulting has developed anti-stress training, anti-burnout training, masterclass "How not to burn in the flames of the profession", a system of webinars for teachers (TNPU, 2020a), some of them were presented at the National Educational Forum, which took place on October 18, 2020, at Ternopil Volodymyr Hnatyuk National Pedagogical University remotely (TNPU, 2020a,d). During the educational forum, 96 teachers took part in activities proposed by the Center of Pedagogical Consulting. Shortly, it is essential to develop masterclasses and webinars on the problems of self-regulation, prevention of professional deformations of teachers, increase of their stress resistance, and development of resilience, which, under the quarantine restrictions associated with the COVID-19 pandemic, will be carried out remotely.

5 CONCLUSIONS

A teacher's occupational health is one of the factors of professional suitability, an important condition for the effectiveness of pedagogical activities, and an indicator of the quality of professional life. The state of occupational health of a teacher affects the results of educational activities and the stability of work results, determines the self-efficacy of teacher's personality.

Preserving and strengthening occupational health of teachers is a strategic task of modern society and the New Ukrainian School, an urgent problem of pedagogical and psychological science. Teacher's health activities involve constant monitoring of occupational health, which is a prerequisite for determining the content and form of consulting services.

The analysis of the results of the study of teachers' occupational health allowed to identify problems that have been exacerbated by the quarantine caused by the coronavirus pandemic, in particular: increasing negative trends in psychological well-being and emotional state, their deterioration in distance and blended learning; increase in anxiety; inability to receive timely psychological help in resolving personal and professional issues; increasing the number of teachers who are dissatisfied with their professional activities; increasing the number of teachers in need of psychological support and help; generally not very responsible for their own occupational health. General condition and features of occupational health of teachers are analyzed, taking into account the length of work in school, type of school, gender, which is very important for determining the content of consulting services.

In preserving and strengthening occupational health of teachers, it is important to operate the Center of Pedagogical Consulting, whose activities are aimed at: acquaintance with modern technologies for maintaining and strengthening occupational health; development of emotional-value, responsible attitude of teachers to occupational health; increasing the level of motivation, maintaining the “professional form”; development of the subjective position of a teacher as a carrier of a sensible way of life; increasing the level of professional stress resistance; prevention of occupational burnout; prevention of professional deformations and destructions of teachers; formation of their resilience; conducting personal and professional growth pieces of training, anti-burnout pieces of training, anti-stress pieces of training, round tables, masterclasses; advisory assistance.

Due to the quarantine measures caused by COVID-19, developments using digital technologies are required: webinars, online masterclasses on prevention of professional deformations of teachers, anti-burnout training, anti-stress training, personal and professional growth training, round tables to increase professional stress, prevention of emotional burnout of teachers, in general ensuring their occupational health. Need to implement the Center of Pedagogical Consulting in the coordinates of occupational health of teachers and technology of social and psychological resilience to develop skills to overcome crises with the least emotional or psychological losses.

We see the prospects for further research in identifying gender differences in teachers’ implementation of occupational health strategies and the formation of the appropriate content of psycho-correctional work remotely under the conditions of the quarantine restrictions associated with the COVID-19 pandemic.

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MOOCs Types and Course Development

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Keywords: Massive Open Online Courses, cMOOC, xMOOC, Quasi MOOC, MOOCs Video Design, Online Course, E-Learning.

Abstract: Massive open online courses (MOOCs) are the new additional dimension of education that allow to study online courses from different universities geographically located anywhere around the world. We consider the MOOCs classification based on pedagogical approaches and product functionalities (cMOOC, xMOOC, quasi MOOC). We present diagrams of the planning, prior preparation and the development of the MOOC. There are four stages of the process: preproduction, production, postproduction and maintenance. We present the typical roadmap of MOOC development: guidelines to develop course content, video content implementation, and development of roles. We introduce as example the video content matrix of the quasi-MOOC "Unity Augmented Reality for Beginners". We recommend the following roles for the MOOC development team: experts, curriculum designers and technical specialists. This set of roles needs for effective design of MOOC.

1 INTRODUCTION

The educational community has begun to use since 2008 the term – *massive open online courses* (MOOCs) to denote a certain format of open online courses. According a study (Shah, 2020b) conducted by the MOOC Class Central by the end of 2020 the size of the modern "MOOC movement" reached more than 950 universities, more than 180 million students (excluding China); the number of MOOC courses are more than 16,300. According (Shah, 2020a), one third of the learners that ever registered on a MOOC platform joined in 2020. The pandemic brought many people into online education. MOOC providers, in particular, attracted many learners with free online courses from top universities.

The largest provider of online courses Coursera (https://www.coursera.org) has expanded its audience to 76 million learners, edX (https://www.edx.org) – 35 million. Duolingo (https://www.duolingo.com), a popular language platform, has more than 300 million users (they do not receive formal certification, in contrast to the previously mentioned 180 million university students).

The top MOOC providers (Coursera, edX, and FutureLearn) registered as many new learners in April 2020 as in the whole 2019 year. Around 25–30% of their total registered users on these MOOC platforms came after the pandemic. Coursera added the largest number of new learners (more than 35 million enrollments between March 2020 and July 2020).

Online learning helps students to improve their performance. Different online learning environments (OLE) have their own way of systems implementation. Technological developments made it a lot easier to develop and customized learning solutions that are focused on adaptive and personalized e-learning environments. OLE platforms can be adapted by higher institutions to enhance teaching and learning process. MOOC provides quality to e-learning from experts without almost no costs.

Despite the growing number of educators who have started to develop the MOOC courses, the design of the MOOC is not simple. Educators (developers of the MOOC) should be familiar not only with pedagogical approaches, but also with logistical, technological and financial issues. They need to plan carefully the feasibility of the course depending on the available resources. The authors of the paper (Alario-Hoyos et al., 2014) propose the conceptual environment "MOOC Canvas" to support teachers in the description and design of the MOOCs.

The desire of educational institutions to improve the quality of education leads to the need to increase the cost of the development and maintenance for educational services, and, consequently, the final cost of training increases. In the economic scale, the MOOCs

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model reduces the cost of learning per student. For example, if $300,000 were spent on the development of one MOOC with an audience of 100,000 students, then we got about $3 per student (Saltzman, 2014, 2017). MOOC companies need to cover the startup costs and financing activities. For example, Coursera in November 2013 attracted $85 million of venture capital, including funding from partner universities, the World Bank and venture capital companies. MIT and Harvard University allotted $30 million each, creating EdX.

The original concept of the MOOC assumed that MOOCs are free courses with open access for a huge number of learners from all over the world. In recent years a large number of researchers have discussed the development of MOOCs in terms of social, institutional, technological, and economic issues. However, this discussion does not pay enough attention to the issues of quality design of the MOOC both in the technological and pedagogical perspectives.

Prospects of MOOC learners, quality criteria in MOOC design are presented in the paper (Yousef et al., 2014). In the study (Shoufan, 2019) authors tried to find out what motivates students to give a positive or negative rate to an educational video. This study can help not only students searching for educational videos but videos developers towards improved content quality and learning outcomes.

Conole (Conole, 2016) presented the 7Cs (Conceptualize, Capture, Communicate, Collaborate, Consider, Combine, Consolidate) Learning design framework, which can be used to develop pedagogically based MOOCs. Daradoumis et al. (Daradoumis et al., 2013), Gros and García-Peñalvo (Gros and García-Peñalvo, 2016) analyzed the state of development of MOOC, studied Open Educational Resources (OER), providing strategic opportunities for improving the quality of education. Romero and Ventura (Romero and Ventura, 2017) presents a comprehensive overview of the data management applications that are used to analyze MOOCs. Periwal and Rana (Periwal and Rana, 2017) presented 4 models for dropout prophecy in MOOCs. After an empirical analysis and evaluation of these models, Periwal and Rana (Periwal and Rana, 2017) concluded that for imbalance MOOC class data the model created by the naive Bayes technique is more appropriate. Cook (Cook, 2017), Shahzad et al. (Shahzad et al., 2020), Fidalgo-Blanco et al. (Fidalgo-Blanco et al., 2016) suggested a methodology for modeling the audience of learners for MOOC. Cook (Cook, 2017) introduced the Open Learner Model. Hew and Cheung (Hew and Cheung, 2014) presented a review of the literature focusing on the MOOCs use by instructors or students. They suggested reasons why students sign up for MOOCs: (1) the desire to learn about a new topic, (2) to extend current knowledge, (3) for personal challenge, and (4) the desire to collect completion certificates. Baanqud et al. (Baanqud et al., 2020), Liyanagunawardena (Liyanagunawardena, 2015), Kaplan and Haenlein (Kaplan and Haenlein, 2016), Gené et al. (Gené et al., 2014) provides a large overview of the methods and techniques for assessing students who study courses through the MOOC platform. Some other studies of the MOOCs learners behavior, MOOC instructions, curricula described in the papers (Bralić et al., 2015; Wang and Chou, 2015; Long, 2017; Gentile et al., 2020; Gunawardena and Premawardhena, 2020; Atapattu and Falkner, 2018; Romadhon et al., 2020; Borrego, 2019). The predictive analysis, economic aspects of MOOCs presented in the papers (Mubarak et al., 2021; Ma and Lee, 2020; Epelboin, 2017).

This article is a continuation of the author's studies presented in (CP4B, 2016; Seidametova, 2016; Seidametova and Moskaleva, 2017; Seidametova, 2018) in which the technological, social, logistical and financial aspects of MOOCs were analyzed.

2 CLASSIFICATION AND COMPARISON OF MOOCS

There is an institutional classification of MOOC (Conole, 2016). For our purposes, more useful is the classification based on the pedagogical approaches and training functions of MOOC. Depending on the pedagogical approaches, there are following main types of MOOCs:

1. cMOOC (connectivist MOOCs) is associated with a socially-constructivist pedagogical approach to learning. cMOOC uses blogs, wikis, social media for searching knowledge. The main interactions take place in the formats "learner-learner" and "learner-teacher". The MOOC as acronym appeared in context of connectivism.

   The main focus of the cMOOC is the accumulation of knowledge, creativity and communication of participants. The Web 2.0 platform is used. cMOOCs allow learners throw the Facebook, websites, Google meetings, Zoom, Discord, Telegram and etc. to share materials. information with the groups The pedagogical approach used in the cMOOC is flexible and sensitive to the specific needs of the participants. It helps to find like-minded people and gives an opportunity to expand the network of contacts. Examples of platforms that use the cMOOC approach are SoloLearn (42 million users), Duolingo (300 million users).

The aim of cMOOC is to improve the quality of education through the strengthening of horizontal links and the stimulation of joint cooperation in groups of learners.

2. xMOOC ("MOOC as eXtension of something else") uses the behavioral principle of acquiring knowledge, by repetition and testing of knowledge. xMOOC contains lectures, quizzes to test the mastery of theoretical material, forums for communicating with the instructor and other students of the course. This brings together xMOOC with the format of the traditional academic courses. Usually, students must comply with the deadlines for submitting completed assignments.

   The content of the courses is focused on duplication of knowledge. The goal of xMOOC is effective delivering of content to a wider audience. Three key components of xMOOCs are content, evaluation and communication.

   xMOOC uses its own technology platform. Three main providers Coursera, edX, and Udacity use xMOOCs.

   The terms cMOOC and xMOOC were introduced by Stephen Downes, one of the creators of the first cMOOC (Kaplan and Haenlein, 2016).

3. Quasi MOOC uses online training, offers online courses, representing an online resource, for example, such as open courses: Khan Academy or MIT OpenCourseWare. Online quasi MOOCs are developed by teachers that can be not certified. Quasi MOOCs are shorter MOOCs for contents and skills and do not require a semester course structure.

   The purpose of the quasi MOOC is to provide access to collections of free learning of the mini-lections in various disciplines and for different age groups of students. Quasi MOOCs can be content-based (xMOOCs), task-based, network-based (cMOOCs).

4. hMOOC is the hybrid MOOC or MOOC 3.0. This concept supports hybrid or flipped classes (blended learning), integrates and combines online and face-to-face teaching/learning.

In addition to the listed MOOCs, there are also SPOC (small private online course) (Seidametova, 2016), COOC (corporate open online course), BOOC (big open online course), aMOOC (adaptive massively open online course), bMOOC (blended massive open online course) (Kaplan and Haenlein, 2016), sMOOC (semi-massive open online course) (Conole, 2016), etc. The terminology in this new field is still not well established.

The pedagogy of MOOCs depends on the following requirements: a curriculum (lessons, exercises, learning results), video and interpretations, forums (as interfaces for learning), jobs, exams and projects. Table 1 illustrates the differences between cMOOCs and xMOOCs.

Table 1: Differences between cMOOCs and xMOOCs.

cMOOCs	**xMOOCs**
Self-organized	Teacher-based
Networked	Centralized
Content: learner generated	Content: teacher-defined
flexible, distributed, video lecture	short assignment, video lecture
Self- and peer-assessment, e-test	Quiz, e-test, peer-review, certificate
Open networking communication	Limited interaction
Communication outside MOOC platform	Built in the MOOC platform

3 LOGISTIC OF THE MOOCS DEVELOPMENT AND DEPLOYMENT

Based on the author's experience acquired in the development of the MOOCs, we present the logistics chain of MOOCs development and deployment on the figures 1, 2, 3. These presentations allow understanding the scope of the preliminary training (planning), as well as organization and management work.

The development of the MOOCs begin with a preparatory stage, during which it is necessary to understand the domain area, identify the target audience, determine the development tools, and calculate the project parameters (cost, capacity, quality, and duration). At the end of this stage, a plan-project should be prepared. Then the organizational stage begins – designing the course, preparing the material, selecting trainers, solving copyright problems, preparing video materials, etc. All this is displayed in the production plan. After preparing scenarios for lessons, videos, tests, interviews, the penultimate stage of development begins – the management stage. This stage implies marketing, course assembly, approbation. The last stage of development is the launch of the course.

At the stage of preliminary preparation of the

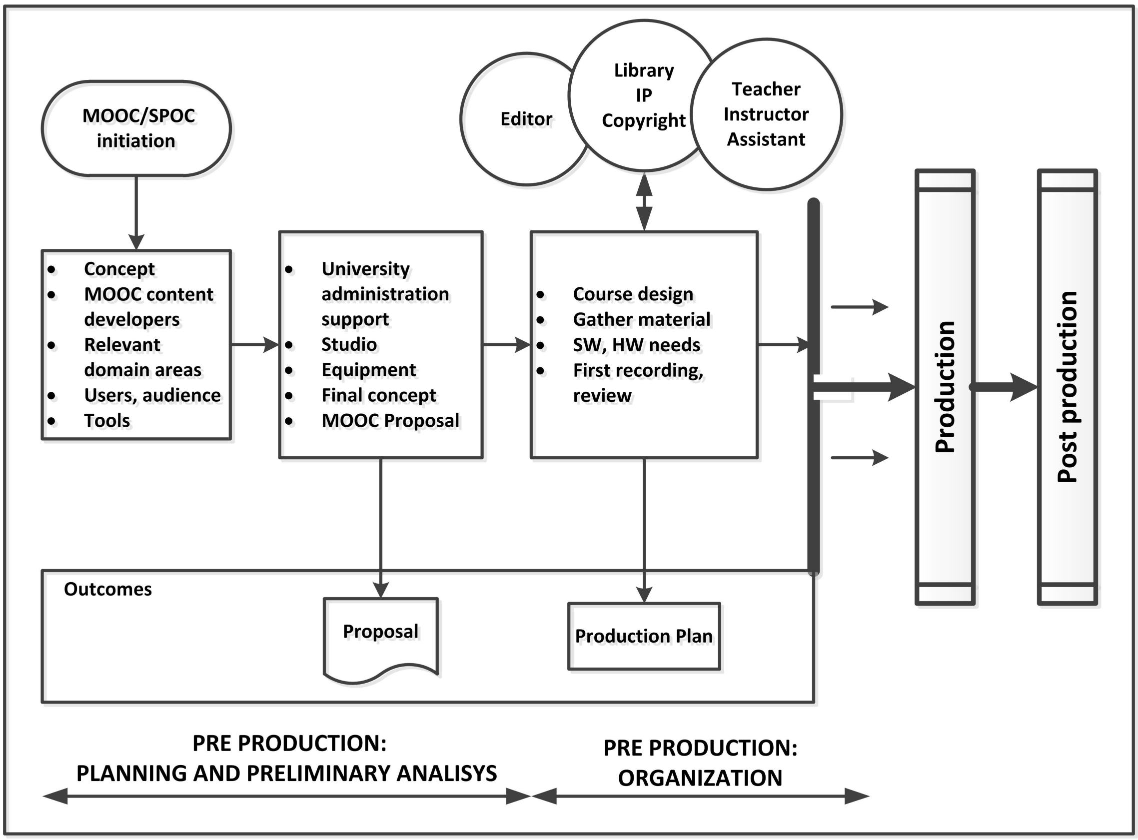

Figure 1: The MOOC preproduction process.

MOOC it is necessary:

1. Identify the narrowed, desired learning outcomes for students.
2. Provide a strategy for evaluating students, verifying the mastery of knowledge in accordance with specified learning outcomes.
3. Develop a sequence of tasks and actions that will support the student's actions in mastering the learning objectives (knowledge, skills, activity):
   - Availability of content that will support active learning; model of activity / skills for students.
   - Duration of the course, the course building from basic knowledge to higher order of skills, such as application, integration and analysis.
4. Ensure a balance between the presence of the teacher / instructor, social and expert cooperation, and the presence of cognitive challenges.

For the pedagogical design of each week (each session) of the course, it is necessary to allocate: planned results, content, activities, evaluation.

4 VIDEO CONTENT MATRIX BY WEEKS OF STUDY

The matrix of video content for the weeks of study should correspond to the expected learning outcomes. It is a kind of template for displaying educational material. Table 2 presents the video content matrix of the MOOC "Unity Augmented Reality for Beginners" (UnityAR4B) (see also figures 4, 5) prepared in the framework of research work by graduates of Applied Informatics major at the Crimean State Engineering-Pedagogical University. The students prepared 8 videos with duration of 3-5 minutes each (the videos can be viewed on our YouTube channel CP4B, https://t.ly/c3b4). The language of these lectures and videos is Russian.

We can make the following recommendations on the variety of presentation forms of the video content. These recommendations are based on the experience of the videos production. Video content for the MOOC can be represented by following video options:

- An introduction to the topic or subtopic with the explaining teacher on the screen: the head or

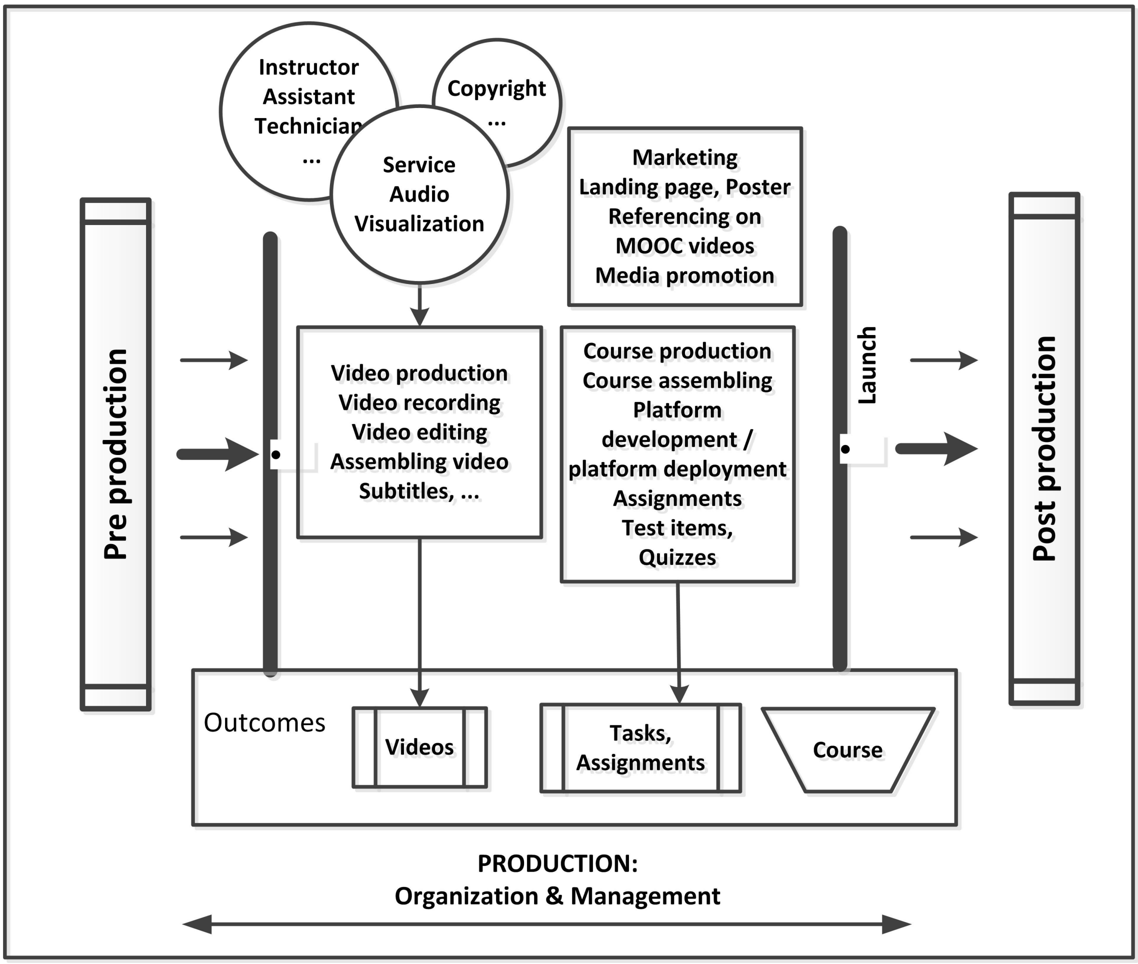

Figure 2: The MOOC production process.

1/3 of the upper part of body. This option usually uses to activate the previously studied material. It contains background information (formulas, schemes, diagrams, etc.), presents the learning objectives of the topic.

- The optimal video length between three and six minutes.
- Voice guidance of the video cast with the presentation of the educational material. We can see on the video slides of the presentation, screen cast, annotations using the tablet or iPad, frames, programming environment, etc.
- Video taken in a specially equipped room or in a certain location – if it is acceptable, the instructor can be placed in a different context for connection with key concepts or with the professional community.
- Interviews – for example, it can be a short interview with a regional representative, or an expert on a given topic.
- The screencast format allows the instructor to include point slides, images, or motion (for example, hand drawing on the board).
- Simulations can be used for illustrating course concepts and engaging students, such videos can be linked to an assignment or learning activity.
- Summarizing – the instructor / teacher summarizes the topic and gives the guidelines for the next topic, i.e. establishes a link between the topics.

5 TOOLS FOR VIDEO PROCESSING

Designing video for learning purposes is something like a conceptual challenge. Gunawardena and Premawardhena (Gunawardena and Premawardhena, 2020), Atapattu and Falkner (Atapattu and Falkner,

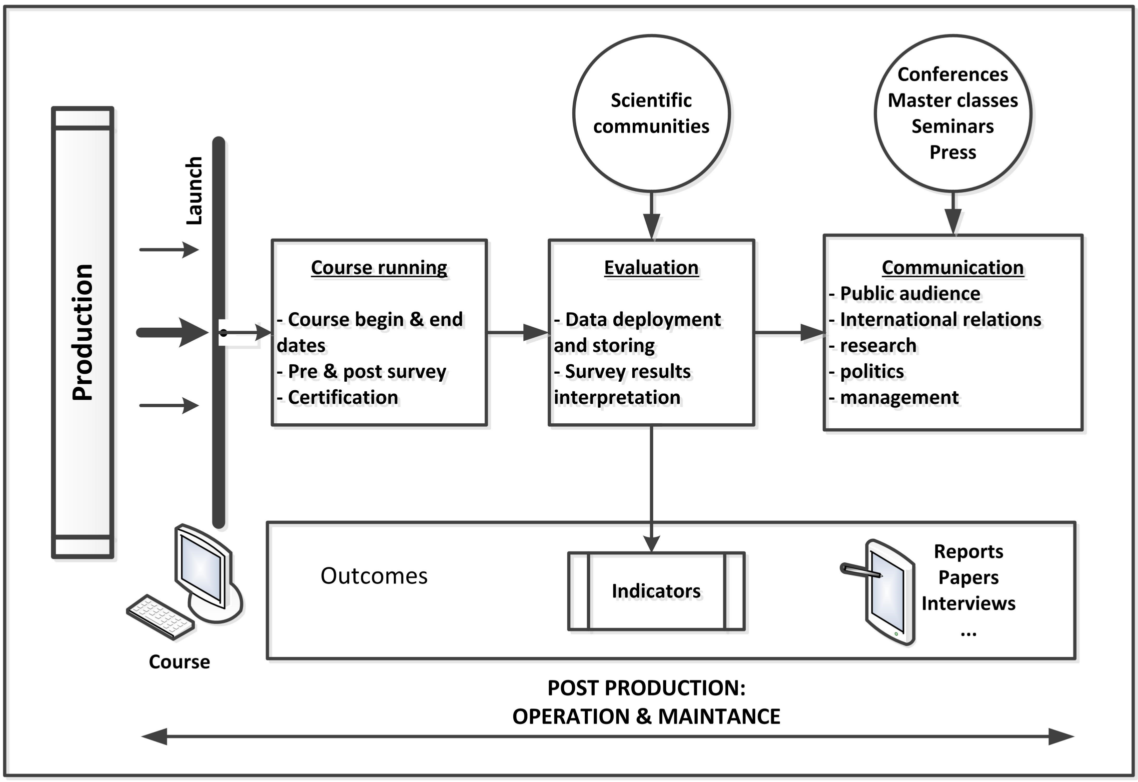

Figure 3: The MOOC postproduction process.

2018), Romadhon et al. (Romadhon et al., 2020) show that videos used in a presentation mode foster passive watching instead of reflective-learning activities.

To prepare the video content, it can be used one of the video processing software:

- Edius (http://www.grassvalley.com/products/subcat-editing_software) – proprietary video editing software for computer running Windows, the latest version is Edius 9.10.
- Camtasia Studio / Camtasia for Mac (https://www.techsmith.com/camtasia.html) – shareware software for capturing video from the screen, allows to record audio from a microphone, and allows to place on the screen videos from a webcam.
- ScreenFlow (Mac) (http://www.telestream.net/screenflow/overview.htm) – proprietary commercial software for the macOS operating system, Apple Inc. for screen casting and video editing.
- Apple iMovie is a video editing software application for macOS, iOS devices.

6 POSSIBLE ROLES FOR PARTICIPANTS OF THE MOOC DEVELOPMENT TEAM

The MOOC involves many staff – the teaching team that designed the course, the teaching team that led the course, researchers, university staff, tutors.

To effectively design and develop a high quality MOOC, the development team needs the following roles, representing domain experts, curriculum designers, and technically skilled specialists. Based on the experience of preparing the MOOC "Web-framework Ruby on Rails for beginners" (RoR4B), these roles can be described as follows:

- Head / expert on educational technologies – conducts consultations and gives recommendations on MOOC planning, an educational strategy, administrative process, resources, educational policies.
- Instructor / teacher – allocates the appropriate material for the course, designs the main activities and evaluation, plans to the presentation of the content, the rubric for expert evaluation.
- Copywriter – helps in choosing resources and copyright issues.

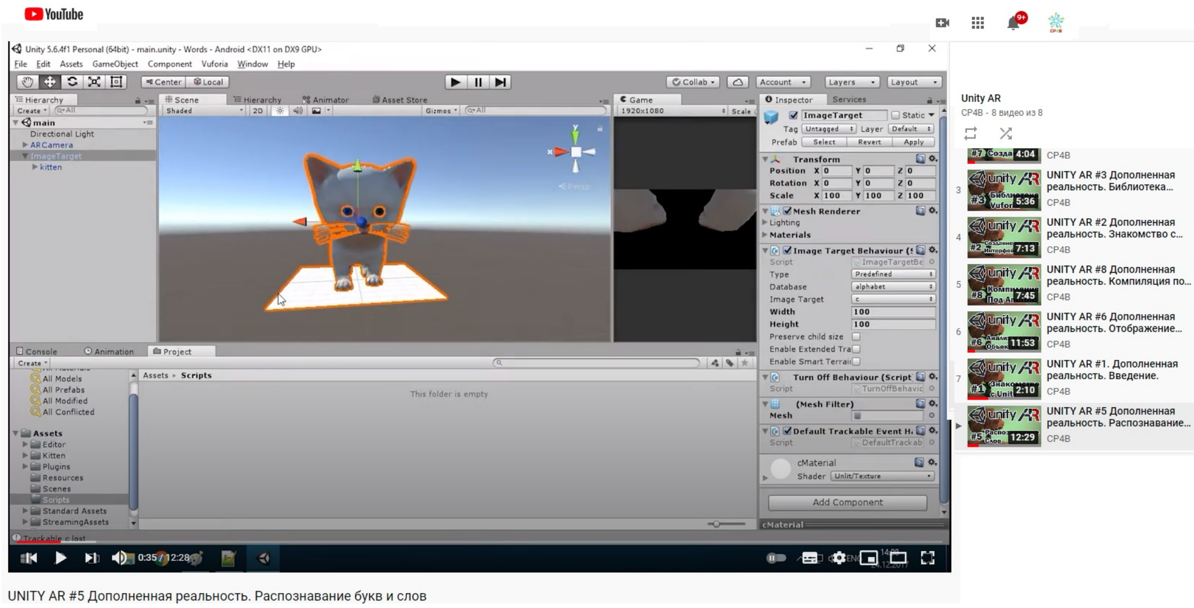

Figure 4: The screenshot of the video 5 "Augmented Reality. Letters and words recognition" from play list of the q-MOOC "Unity Augmented Reality for Beginners" (UnityAR4B).

Table 2: Quasi MOOC "Unity AR for beginners" video content matrix by weeks of study.

	Lesson 1	Lesson 2	Lesson 3
Week 1	1.1 Introduction to Augmented Reality	1.2 Installation of Unity. Unity Interface. Understanding different panels in Unity. Moving, rotating and scaling. Objects in Unity. Physics in Unity	1.3 Vuforia package. Importing Vuforia inside Unity. Capturing an Image. Creating a Vuforia Database. Image Targets
Week 2	2.1 Creating a Canvas and adding a Background image	2.2 The Recognition of the letters and words	2.3 Projecting 3D Model on Image Target. Customizing the letters image target
Week 3	3.1 Designing UI buttons inside the Canvas. Programming the UI buttons. Programming Back and Exit button inside the AR Scene	3.2 Building the app and testing the output	3.3 Compiling AR app to Android devices

- Assistant (TA) – helps in the design of resources, the selection of materials, the preparation of written questions, development and maintenance, for example, in aspects that require special knowledge of content. TA monitors the discussion forums of the MOOC and evaluation components during the activity of this course.
- Video specialist – responsible for the production of video materials, video. Video specialist edits, mounts the original video, creates a video project, and synchronizes the sound with the video image and uploads the video to the MOOC platform, on YouTube.
- The course's producer (CP) – CP edits screen capture components, organizes video in sections (lessons) of lectures. CP adds meaningful questions to the video content / captured screen. CP constructs a survey, homework or evaluation components.

7 CONCLUSIONS

Nowadays MOOCs movements are one of the most innovative initiatives within e-learning and distance education that create new learning opportunities in open and university education. However, there are not consolidated approaches regarding the logistic of MOOCs design and development.

Students who register for MOOC pursue differ-

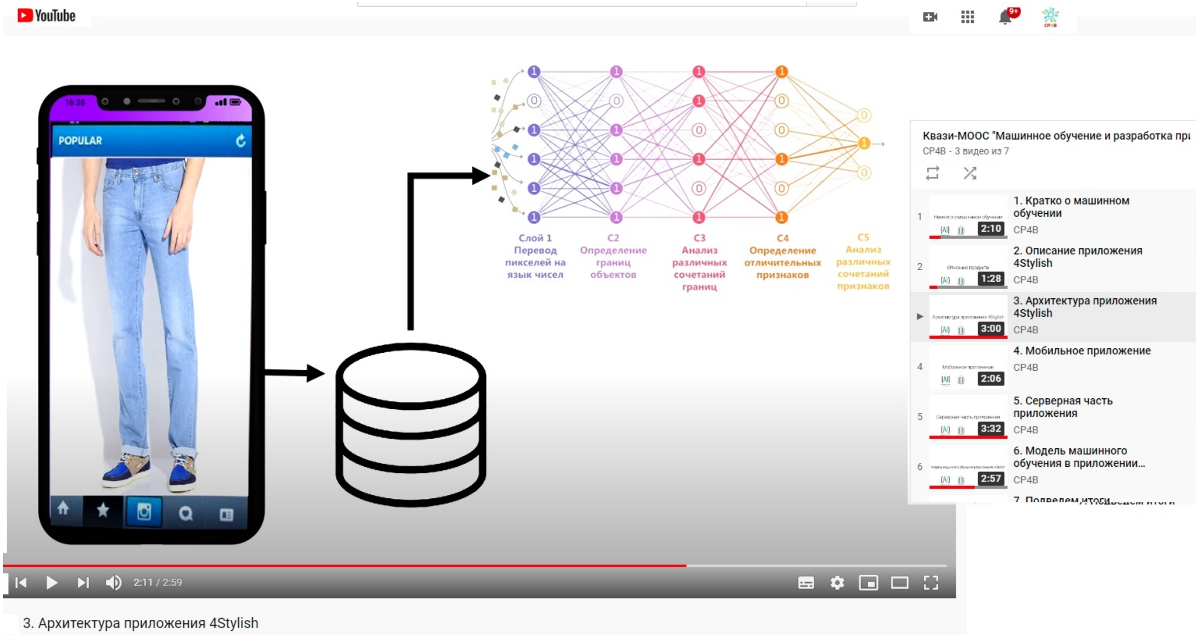

Figure 5: The fragment of the video "Architecture of the 4Stylish Application" from play list of the q-MOOC "Machine Learning for beginners" (ML4B).

ent goals. Designing the MOOC as training course, it is necessary to take into account all the wishes and opportunities of the learner's audience. The implementation of the MOOC described in the article, is a typical MOOC development roadmap: recommendations for content preparation, video content, automatic evaluation, role-based specifications.

The roadmap is derived from the experience of developing MOOC in the discipline "Unity Augmented Reality for beginners" (UnityAR4B) (CP4B, 2016). In the future it is planned to develop statistical tools for this MOOC, as well as to study personalization issues that will take into account the desires and opportunities of students.

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Ensuring the Effectiveness of e-Learning based on Online Technology Analysis of Factors Influencing the Cognitive Independence of Students

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Abstract: The problem of improvement of educational technologies in connection with the revealed problems, aggravated in the conditions of COVID-19, is considered. A new approach to building a system of flexible learning, based on “tuning” the technologies of student interaction with the educational environment, is proposed. Such adaptation is carried out using the mathematical model of educational process control developed by the authors, the parameters of which are characteristic of the factors that form the cognitive independence of students.The presented information technology for assessing the factors that shape the cognitive independence of students can be integrated into any educational system due to the universal capabilities that Google services provide. The developed technology is very useful for studying the real picture of individual factors of cognitive independence in the educational process, organized with the help of electronic educational technology. The main functional capabilities and advantages of the developed information technology are: the ability to organize adaptive learning, the ability to organize questionnaires in any electronic educational system, simplicity and ease of use, modular structure, and others.

1 INTRODUCTION

The current educational revolution (Reid, 2006; Bersin, 2004; Blaschke, 2012; Cochrane et al., 2013), the rapid technology of e-learning (caused by COVID-19) (Joshua et al., 2016; Pereira and Rodrigues, 2013) and the concept of lifelong learning (Al-Qahtani and Higgins, 2013; Voloshinov et al., 2020) exacerbate the following problems:

- quality of e-learning environment (Verkhova and Akimov, 2017; Lavrentieva et al., 2021),
- adaptive learning (Kotova and Pisarev, 2017; Atto and Kotova, 2020; Haranin and Moiseienko, 2018),
- ergonomic support of the educational system (Lavrov et al., 2017),
- formation of cognitive independence (Burov, 2017; Pinchuk et al., 2020).

The analysis of these scientific articles shows that the main task of improving and ensuring the effectiveness of e-learning is to enhance the cognitive independence of students. In modern literature, cognitive independence is defined as follows (Lavrov et al., 2021): ”Cognitive independence is an integrative property of a student who learns using a computer, associated with the student’s initiative and the search for various alternative ways to solve problems without the participation of tutors”.

2 PROBLEM STATEMENT

A problem arises: “How to ensure the cognitive independence of students in the conditions of electronic

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education?".

Lavrov et al. (Lavrov et al., 2021) outlines approaches to the analysis of factors that affect the cognitive independence of students. However, the question remains: "How to implement such a study in practice?".

Consider the most well-known digital content management systems designed to organize learning processes using Internet technologies (table 1). For almost all of these platforms, the main goal is to organize access to teaching materials, ensure interaction, testing and reporting between teachers and students.

One of the most common distance learning systems in universities is the Moodle system, an educational platform that aims to connect teachers, administrators and students in a reliable, secure and integrated system to create a personalized learning environment (Moodle Docs, 2020; Abdula et al., 2020).

The technical aspects of the system can be described as follows:

- Moodle is written in PHP using a SQL database,
- Moodle is installation packages and detailed installation files,
- Moodle represents different categories of users: administrators, teachers-developers, teachers, students, and guests.

Moodle has a wide range of features that are specific to e-learning platforms (Moodle Docs, 2020). This allows you to organize all stages of the learning process: diagnosis, planning, training, management of educational activities, evaluation of results.

To diagnose and assess certain learning phenomena in the Moodle system, the following technologies are provided:

1. Questionnaire module is an activity that provides many proven survey tools used to assess and encourage learning in the Internet environment. Teachers can use them to collect data from students to help them understand the class and think about their own teaching (Moodle Docs, 2020). There are three types of questionnaires:
   - ATTLS – Attitudes toThinkingandLearning Survey a questionnaire containing 20 questions, designed to determine the level of students' attitudes to distance learning,
   - COLLES – Constructivist On-Line Learning Environment Survey (questionnaire "Learning Environment withEelements of Constructivism") a questionnaire containing 20 questions, designed to determine the level of students' attitudes to distance learning,
   - Critical Incidents (questionnaire "Critical Incidents") is a questionnaire in which students are given the opportunity to assess certain events and their attitude to what is happening.
2. Survey module (choice) – in the classroom, you can ask questions and set switches, and students can press these switches to choose from a number of possible answers. They can choose one or more options, and if pre-settings allow, they can update their selection. The options can be used as a quick survey to stimulate reflection on the topic, to allow the class to vote for the direction of the course, or to assess progress (Moodle Docs, 2020).
3. Module test is an activity that allows teachers to develop and build tests of knowledge, consisting of many types of questions, including multiple choice questions, right or wrong questions, short answers and correspondence, and numerical questions (Moodle Docs, 2020).
4. The provided technologies can diversify distance learning courses and make them "alive".
5. Although these technologies have certain diagnostic capabilities, we believe that the main disadvantage of the questionnaire module is its static nature:
   - you cannot edit the questionnaire,
   - other questions cannot be entered (they can only be used in the same form as specified by the developer).

Therefore, when teachers want to create their own questionnaires to diagnose certain aspects of assessment of learning phenomena, problems arise because this is not provided in the system.

As the analysis of the literature shows, modern e-learning systems do not allow to investigate the importance of factors that affect cognitive independence (in order to increase the effectiveness of learning).

Modern e-learning technologies have a wide range of organizational capabilities at all stages of learning, including diagnostic tools, but they are static in nature, and the scope of assessment of learning phenomena in them is limited.

Thus, despite the large number of studies in the field of adaptive learning, including (Osadchyi et al., 2020), the practice of most universities has shown a lack of effective online learning in a pandemic. The following facts have been recorded: decreased motivation, decrease in the quality of the educational process, refusal to study, stressful situations both among students and teachers.

The main issues are related to the following disabilities: operational research of motivational param-

Table 1: The most popular educational platforms.

Platform	Description
Moodle (https://moodle.org/)	The platform integrates teachers, administrators and students (students) into a reliable, secure and integrated system to create a personalized learning environment
Google Classroom (https://classroom.google.com)	Google's web service, designed for educational institutions to facilitate the creation, distribution and classification of tasks, making them paperless
edX (https://www.edx.org/)	A platform that provides a large number of courses for various purposes from the best universities and colleges in the world
Coursera (https://www.coursera.org/)	An educational platform that provides online courses from the world's leading universities and organizations
FutureLearn (https://www.futurelearn.com/)	Online course platform in the UK
Khan Academy (https://www.khanacademy.org/)	Free online courses and courses
Schoology (https://www.schoology.com/)	A virtual learning environment for schools and universities that allows users to create, manage and share learning content
Classdojo (https://www.classdojo.com/)	A communication platform for distance learning in school, used by teachers, students, and parents
Seesaw (https://web.seesaw.me/)	A platform for creating digital learning resources
Skooler (https://skooler.com/)	Tools for turning Microsoft Office software into an educational platform
CenturyTech (https://www.century.tech/)	A platform that has tools for distance learning

eters and characteristics of students' cognitive independence, and customizing the educational process for the characteristics of the student.

In this regard, define the purpose of this study: a) develop information technology for analytical research of factors influencing the effectiveness of distance learning in conditions caused by a pandemic; b) develop the principle of building a model that provides "customization of learning technology for a particular student studying in a particular educational environment".

3 RESULTS

3.1 Development of an Approach to Building a Model of Adaptive Formation of Cognitive Independence in the Context of Pandemic Constraints

We will consider a typical situation typical for the organization of the educational process at the university (Lavrov et al., 2017):

1. The working curriculum for the discipline has M topics.
2. Each topic has a basic conceptual part (these are the basic provisions of the topic that are stable for a long time), as well as a variable part (educational material, the content of which may vary depending on the technical process of the educational process, software of the educational process, personal experience, own knowledge, scientific or methodological advantages, etc.).
3. For each i-th topic in the program, the time t_i, which can be represented as $t_i = t_{i1} + t_{i2}$, is allocated, where ti1 is the time allotted to the conceptual part and t_{i2} is the time allotted to the variable part.
4. For each i-th variable part, there are N_i variants j of its presentation.
5. With each i-th variant $(j = 1, N_i)$ of the topic i $(i = 1, M)$, it is possible to connect some function of usefulness of presentation of the maintenance of the j-th variant for formation of cognitive independence. Usefulness cannot be measured directly. Its indirect assessment may be a number – the rank of R_{ijl} – which is attributed by the expert to the j-th variant in the i-th topic from the standpoint of the influence of educational material of the j-th variant on the formation of the l-th component of cognitive independence. Ranks are formed by the method of rank correlations. According to this method, the j-th variant is assigned a rank of

1, if in the opinion of the expert, this variant is the most useful for the formation of the cognitive independence in the i-th topic; the second most important variant of presentation is assigned a rank of 2, etc. Ranking of variants of teaching material is carried out for each l-th informative component of the cognitive independence.

6. To implement the selection process, a logical variable x_{ij}, is introduced, which takes on the value 1 if the j-th option is selected when presenting the i-th topic, and the value 0 otherwise.

Given the assumptions made, the task of forming cognitive independence can be formulated as follows:

Known:

- the number M of topics of educational material of the discipline,
- the time t_{ij}, allocated for each j-th variable part in each i-th topic,
- the number N_i of j variants of the presentation of each variable part,
- the structure of the properties l (l = 1, k) of the student's personality, the list of which is customary to explicate cognitive independence (in other words, personality properties that form cognitive independence),
- R_{ijl} ranks assigned by experts to the j-th variant of presentation of the i-th topic according to the level of its influence on the l-th parameter of cognitive independence.

It is necessary to choose the following options j for each topic i to maximize the total effect of the educational material on the formation of cognitive independence.

Thus, it is necessary to maximize the sum of ranks, which determines this effect:

$$\sum_{i=1}^{M}\sum_{j=1}^{N_i}\sum_{l=1}^{k} R_{ij}^{l} x_{ij} \rightarrow max, \quad (1)$$

with restrictions:

- on the study of the discipline

$$\sum_{i=1}^{M}\sum_{j=1}^{N_i} t_{ij} \leq T, \quad (2)$$

- on the obligatory presentation of all topics

$$\sum_{i=1}^{N_i} x_{ij} = 1, (i = 1, M), \quad (3)$$

- on the obligatory choice of at least one version of the presentation in each topic

$$\sum_{i=1}^{M} x_{ij} = 1, (j = 1, N_i), \quad (4)$$

- for integer variables

$$x_{ij} \in 0, 1, \quad (5)$$

Explication of the concept of "cognitive independence" allows us to identify a list of personality traits that form a complex quality of personality "cognitive independence", which can be called components of cognitive independence (factors).

Consider an example of a fragment of a set of such factors (determined by experts of Sumy National Agrarian University and the Ukrainian Academy of Engineering and Pedagogy):

- the need and desire to master the knowledge and methods of activity,
- cognitive motive and interest,
- interest in the results of their independent cognitive activity,
- interest in the future profession,
- initiative,
- basic knowledge (possessed by the individual),
- acquired basic skills and abilities, computer skills and possession of previously learned software,
- acquired knowledge of the discipline of the computer cycle being studied,
- acquired skills and abilities in the discipline of computer cycle, computer skills and possession of learned software,
- use of scientific and methodological literature, means of communication, the Internet,
- attentiveness,
- strong-willed efforts,
- purposefulness,
- persistence,
- contact with the teacher during independent cognitive activities in order to obtain information,
- contact with other students during independent cognitive activities in order to obtain information,
- ability to set and achieve the goals of cognitive activities,
- ability to plan their cognitive activities,
- ability to assess their potential in performing cognitive activities,

- ability to evaluate the results of their cognitive activities.

In the notation of the above model, a list of k properties of the student's l personality is formed ($l = 1, k$).

Such sets of factors will be different:

- for different universities,
- for different groups of students,
- for different age groups,
- for different learning technologies, etc.

Therefore, it is necessary to be able to model them in each problem situation.

The main problems of this model are:

- Pr1 – how to embed the model in the distance learning system;
- Pr2 – how to generate source data that really reflects the current problem situation.

We solved the Pr1 problem by creating a special technology of intelligent agent-manager, which is built into any system of distance education (Lavrov and Lavrova, 2019). To solve the Pr2 problem, we offer a special online survey technology, which is described below.

3.2 Information Technology for the Analytical Study of the Factors Influencing the Effectiveness of Distance Learning in the Context of Constraints Caused by a Pandemic

Basic principles of technology:

- use of modern Google Script technology familiar to students and teachers,
- online questionnaire for all categories of participants in the learning process:
  - all teachers,
  - all students
- preliminary formation of factors to be considered (special expert group of teachers and students),
- embedding the questionnaire in the educational process management system,
- formation of results:
  - for each student,
  - for all teachers together.

The results are processed in a special way (Lavrov et al., 2021). Based on expert data, the average value of the degree of P_{avi} manifestation in the structure of cognitive independence, the variance of $S_i$expert assessments, the confidence interval V_i, as well as upper confidence limit P_{upi} values of the informativeness of cognitive independence parameters, lower confidence limit P_{lowi} values of the informativeness of cognitive independence parameters, and the R_{Pupi} rank of the values of the upper limits of the confidence intervals are calculated for each factor. In addition, a line graph for R_{Pupi} and P_{lowi} is built.

Figure 1 and figure 2 show the results that are automatically generated by the system after

- conducting a survey,
- processing questionnaires and determining the informativeness of the parameters of cognitive independence.

It is clear that for each student we receive the individual estimations (figure 1), and it allows system to adjust educational process.

If we analyze the ranks of the factors obtained as a result of the analysis of teachers and students of Sumy National Agrarian University, the most important (fragment) for the conditions of the pandemic (a total of 20 factors were estimated) were identified:

- rank 1 – contact with other students during the performance of independent cognitive activities in order to obtain information,
- rank 2 – the ability to evaluate the results of their cognitive activity.
- rank 3 – contact with the teacher during the performance of independent cognitive activity in order to obtain information.

Such studies allow us: a) to change the general technology of training organization; b) to adjust the learning process for each student.

The main functional capabilities and advantages of the developed information technology are:

- the possibility of organizing adaptive learning,
- the possibility of organizing a questionnaire in any electronic educational system to determine the level of factors in the study of any discipline,
- an opportunity, for example for educational institutions, to introduce disciplines in solving problems related to the quality of teaching,
- simplicity and ease of use,
- modular structure,
- the ability to reach a wide audience of test takers, with access to the Internet,
- the ability to store answers in Google spreadsheets,

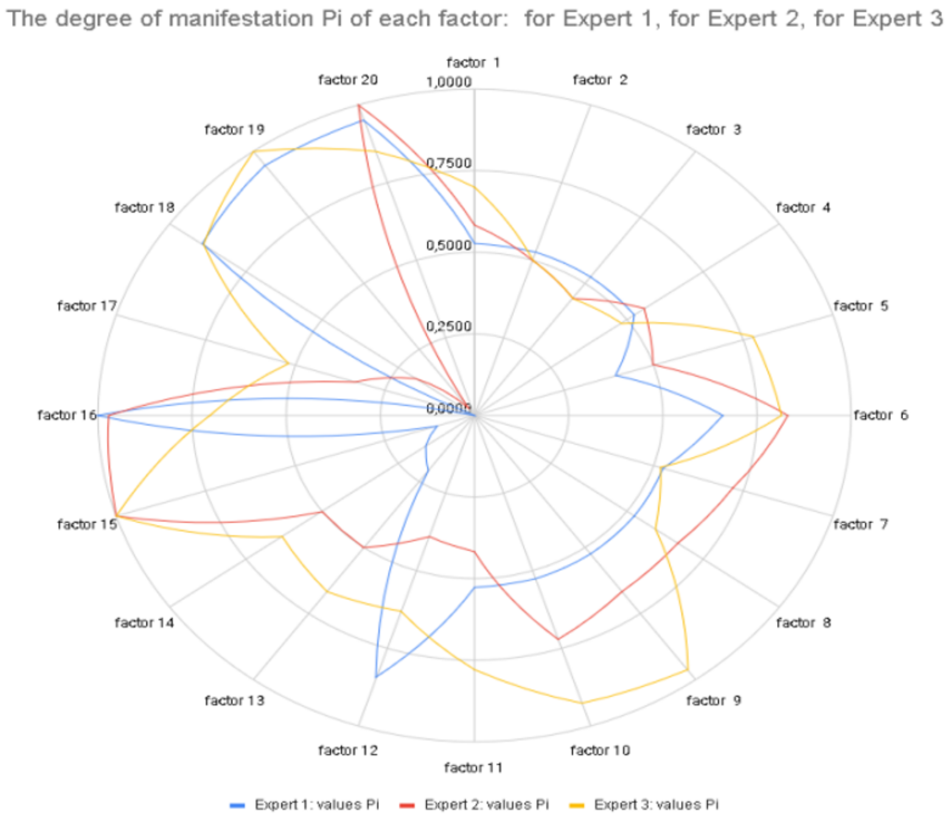

Figure 1: Results (fragment) of data processing by three experts (students) – the degree of manifestation of the components of cognitive independence.

- survey results are stored on Google Drive,
- allows you to set a deadline for receiving answers to questions,
- has sufficiently reliable protection, this applies to both the content of the surveys and the results of the surveys.

3.3 Use of Technology for the Formation of Individualized Training Focused on the Conditions of the Pandemic: Experimental Studies

The technology of revealing individual features of students and the model of individual customization of the educational process "for the student" during the spring semester of 2019–2020 academic year and the autumn semester of 2020–2021 academic year were studied, implemented and tested at the Department of Cybernetics and Informatics of Sumy National Agrarian University (SNAU).

The content of the questions (20 questions in total) that were asked to students is described in clause 3.1 and complies with the recommendations (Lavrov et al., 2021) (however, it is possible to formulate arbitrary questions that are relevant for a particular university).

The main advantage of the proposed method is the ability to flexibly adjust the training to the characteristics of the student and the recommendations of teachers (see table 2).

Satisfaction with the forms of educational process (percentage of positive assessments of the quality of technology, according to materials of the Department of Cybernetics and Informatics of Sumy National Agrarian University) in the pandemic is presented in figure 3.

4 CONCLUSIONS

Existing e-learning technologies do not offer the possibility of flexible operational analysis of factors that determine the quality of the educational process from the point of view of teachers and students, in particular the factors that shape the cognitive independence of students.

In today's e-learning environment, including due

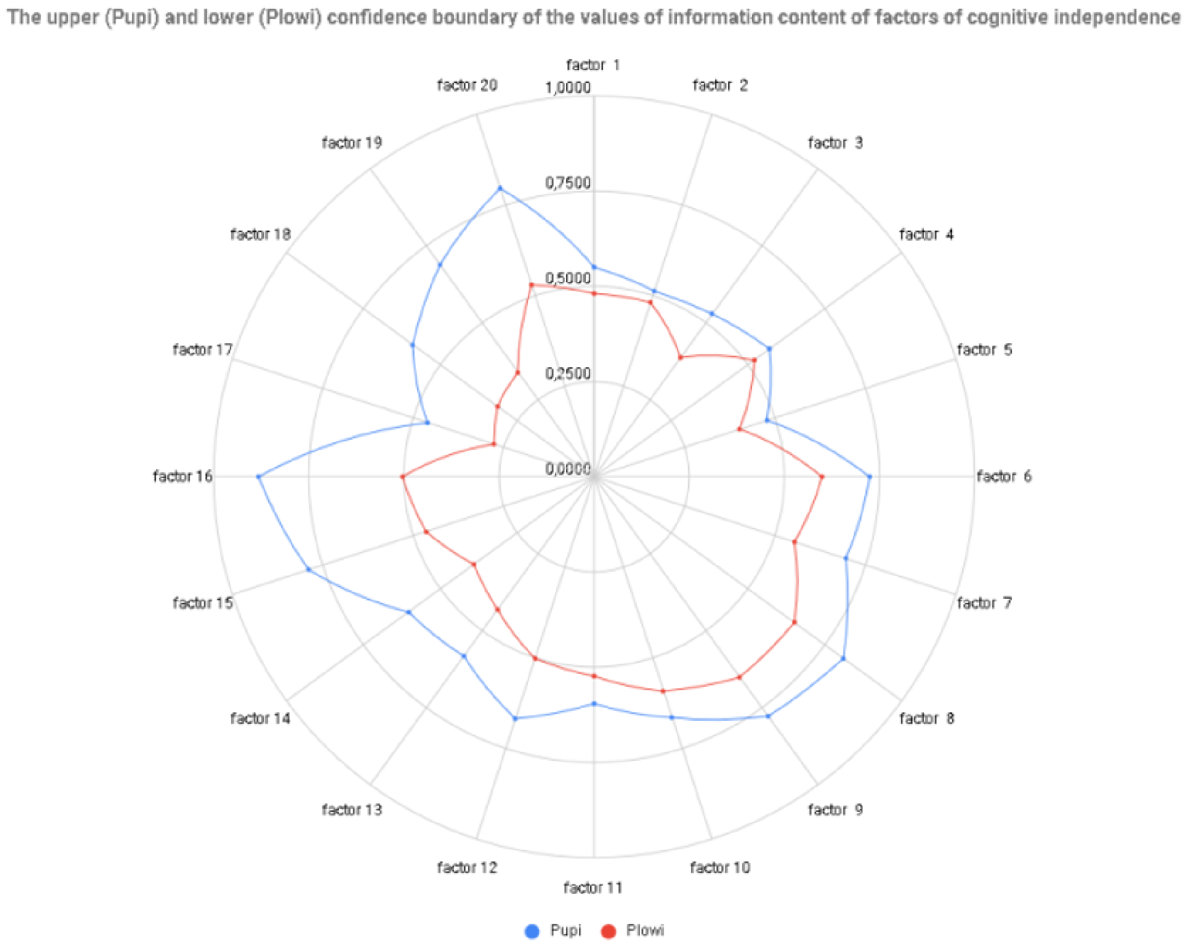

Figure 2: Results (fragment) of data processing: R_{Pupi} and P_{lowi} – upper and lower confidence limits for the informativeness values of the factors of cognitive independence (obtained during the survey of teachers for the conditions of studying the discipline "Information Technology", Faculty of Management, Sumy National Agrarian University).

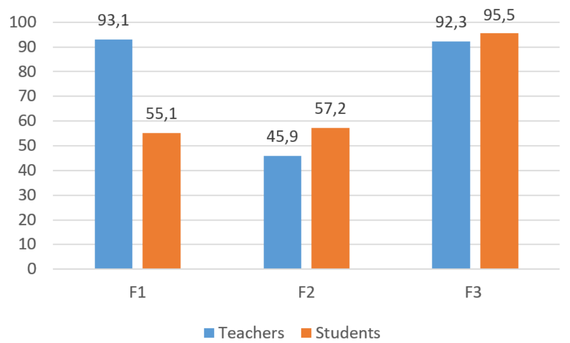

Figure 3: Satisfaction with the forms of educational process (percentage of positive assessments of the quality of technology, according to the Department of Cybernetics and Informatics of Sumy National Agrarian University) in the pandemic.

to COVID-19 restrictions, this is a critical limitation. In this regard, a modern management system of the educational process requires a fundamentally new information technology developed as a result of this study, which includes models and software:

- online surveys of students and teachers,
- prompt processing of survey results with the possibility of ranking the factors influencing cognitive independence in different learning conditions (including pandemics),
- adjustment of learning technologies to the parameters of students identified as a result of online surveys.

The scientific novelty of the result lies in the fact that in contrast to the existing models of adaptive management of the learning process, focused on expert (or selective) assessment of student parameters and learning technologies, built adaptation models use online assessment technologies that allow you to quickly configure the system to a "problem situation".

Testing under COVID-19 constraints has proven

Table 2: Development of approaches to learning technologies (example based on materials of computer cycle disciplines, teacher V. G. Logvinenko, SNAU, Ukraine).

Traditional learning (F1 – Form 1)	**Distance learning (F2 – Form 2)**	**Flexible online learning in a pandemic (adaptive technology) (F3 – Form 3)**
Lectures – 18 hours	Study of lecture materials (on the website) – 18 hours	The volume and forms are adjusted individually according to the results of the online research: • online lecture of the teacher, • video lecture (record), • study of materials for the lecture (text, presentation), • discussion of problematic issues of the lecture with the teacher, • discussion of problematic issues of the lecture in microgroups of students, • games and debates based on lecture materials
Laboratory work – 36 hours	Virtual laboratory work – 36 hours	The volume and forms are adjusted individually according to the results of the online research: • online preparation for laboratory work, • video to study the technology of laboratory work (record), • modeling problem situations “what will happen if”, • discussion of problematic issues of laboratory work with the teacher, • discussion of problematic issues of laboratory work in micro-groups of students, • games, • passing a laboratory course

the effectiveness of the approach. The practical significance of the results lies in the possibility (thanks to the use of Google services) of embedding into any learning process management system.

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Some Geometric Objects Related to a Family of the Ballistic Trajectories in a Viscous Medium

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Keywords: Ballistic Trajectories, Linear Resistance, Envelope for a Family of Curves.

Abstract: Computer geometric modeling is important pre-processing steps in the object's mathematical representation using curves that may be constructed using analytic functions, a set of points, or other curves and surfaces. The paper describes some remarkable curves related to a family of the ballistic trajectories in a viscous medium with a linear resistance. The envelope of the family of trajectories, the trajectory of the farthest flight and the curve of maximum flight altitudes are presented in parametric form. A geometric interpretation of the entire set of ballistic trajectories in the form of some surface (the Galileo's dome) is also presented.

1 INTRODUCTION

Some classical problems of applied mathematics and mechanics seem inexhaustible. Each appeal to them reveals some new facets, highlighting the existence of hidden connections between various areas of mathematics. Galileo's problem about the motion of a body thrown at some angle to the horizon was the first solved problem of dynamics. It was solved by Galileo long before the appearance of the Newtonian mechanics. The solution is given in his last book "Discorsi e Dimostrazioni Matematiche Intorno a Due Nuove Scienze", published in Leiden in 1638. This book was translated from Italian and Latin into English by Henry Crew and Alfonso de Salvio in 1914. Now this translation is available in the Online Library of Liberty (Galilei, 1914).

"Fourth Day: The motion of projectiles" is the chapter title of (Galilei, 1914) treating the problem in the delightful and convincing language of geometry. This language of the era, perhaps, will seem somewhat heavy to the modern reader. But the epoch had no other language. Neither Newton's laws of mechanics nor differential equations existed.

This problem is a traditional and simple task, with which the study of mechanics and physics often begins. The design of the geometric modeling is widely used in Computational Fluid Dynamics (CFD) simulations. Simple and efficient geometric modeling can improve the efficiency of flow field simulations for various applications. Some of the applications described in (Bertin, 2017; Zhou et al., 2017; Ma et al., 2019).

We will consider in this paper some new geometric objects related to this problem.

In the paper (Seidametova and Temnenko, 2020) we considered the simplest Galilean version of this ballistic problem, assuming that only gravity acts on the flying object. In this paper we examined the ballistic problem in a viscous environment. We will assume that, in addition to gravity, a viscous resistance force $\vec{\mathbb{F}}_R$ acts on the flying object, which is linearly dependent on the speed of movement $\vec{v}$:

$$\vec{\mathbb{F}}_R = -b\vec{v}. \tag{1}$$

The constant b characterizes the resistance of the medium. For a physical object at low Reynolds numbers, the value b is determined by the well-known G. G. Stokes formula (Landau and Lifshitz, 1987):

$$b = 6\pi a \rho_m \nu_m, \tag{2}$$

where a is a sphere radius, ρ_m is a density of the medium, ν_m is a kinematic viscosity of the medium.

We take the value of the initial speed of the thrown body v_0 as a velocity unit, the acceleration of gravity g as an acceleration unit. With this choice, the unit of time is $\frac{v_0}{g}$, and the unit of length is $\frac{v_0^2}{g}$. Let t be the time, x the horizontal coordinate, y the vertical

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coordinate (we assume that $y \geq 0$), α is the angle that the initial speed vector makes up with the horizontal line ($0 \leq \alpha \leq \pi/2$).

2 FORMULATION OF THE PROBLEM

Newton's equations of motion are:

$$\begin{aligned} \dot{v}_x &= -\beta v_x, \\ \dot{v}_y &= -1 - \beta v_y. \end{aligned} \tag{3}$$

$$\begin{aligned} \dot{x} &= v_x, \\ \dot{y} &= v_y. \end{aligned} \tag{4}$$

Here the dot above the letter denotes the time derivative, v_x, v_y are the Cartesian components of the velocity $\vec{v}$; β is the dimensionless parameter characterizing the resistance of the medium:

$$\beta = \frac{bv_0}{mg}. \tag{5}$$

where m is the mass of a flying object.

If we assume that the flying object is a homogeneous sphere of radius a and density ρ_b, then, taking into account the Stokes formula (2), the coefficients of viscous resistance β can be given the following form

$$\beta = \left(\frac{9}{2}\frac{\rho_m}{\rho_b}\right) \cdot \frac{\nu_m v_0}{ga^2}. \tag{6}$$

In order for the equations of motion (3) to adequately describe the trajectory, two conditions must be met:

1. The size of the flying body should be much smaller than the characteristic dimensions of the flight path:

$$\frac{v_0^2}{ag} \gg 1. \tag{7}$$

2. The Reynold's number should be small enough

$$Re = \frac{v_0 \cdot a}{\nu_m} \ll 1. \tag{8}$$

Inequalities (7) and (8) limit the initial velocity from above and below:

$$\sqrt{ag} \ll v_0 \ll \frac{\nu_m}{a}. \tag{9}$$

For these constraints to be compatible, the object must be small enough:

$$a \ll \left(\nu_m^2/g\right)^{1/3}. \tag{10}$$

To prevent inequality (10) from being too burdensome, experiments with a flying object should be carried out in a medium with a high viscosity, for example, in glycerin.

The equations of motion (3) and (4) are supplemented by the initial conditions at $t = 0$:

$$\begin{aligned} v_x(t=0) &= \cos\alpha, \\ v_y(t=0) &= \sin\alpha, \end{aligned} \tag{11}$$

and

$$\begin{aligned} x(t=0) &= 0, \\ y(t=0) &= 0. \end{aligned} \tag{12}$$

In the equations of motion (11) α is the departure angle (the angle that makes the body's velocity vector with the axis x at the initial moment). The angle α obeys the condition:

$$0 < \alpha \leq \frac{\pi}{2}. \tag{13}$$

The formulated problem contains one physical parameter β and one geometric parameter α. Changes of α in region (13) at fixed β generates a family of ballistic trajectories. We investigate in this paper how resistance β affects the appearance of a family of trajectories. We considered the trajectories at $y \geq 0$, from the moment of departure of the object to its fall.

Of particular interest are three curves generated by the family of trajectories: the envelope of the family of trajectories, the trajectory of the farthest flight, and the locus of the points of maximum flight altitude when the departure angle changes. In (Seidametova and Temnenko, 2020) a new composite remarkable curve was constructed from these three curves, which we called Galileo's poleaxe. We will look at how the parameter β affects these wonderful curves.

3 TRAJECTORIES OF MOVEMENT

The solutions of the differential equations of motion (3), (4) with the initial conditions (11), (12) have the following form:

$$\begin{aligned} v_x &= \cos\alpha \cdot e^{-\beta t}, \\ v_y &= \frac{1}{\beta}\left((1+\beta\sin\alpha)\, e^{-\beta t} - 1\right). \end{aligned} \tag{14}$$

$$\begin{aligned} x &= \frac{\cos\alpha}{\beta}\left(1 - e^{-\beta t}\right), \\ y &= \left(1/\beta^2\right)\left((1+\beta\sin\alpha)\left(1-e^{-\beta t}\right) - \beta t\right). \end{aligned} \tag{15}$$

Eliminating time t from (15), we can obtain an explicit equation for the family of ballistic trajectories in a medium with linear viscous resistance:

$$y=\frac{1}{\beta^2}\left((1+\beta\sin\alpha)\frac{\beta x}{\cos\alpha}+\ln\left(1-\frac{\beta x}{\cos\alpha}\right)\right). \tag{16}$$

4 THE LOCUS OF THE MAXIMUM LIFTING HEIGHTS OF THE TRAJECTORIES

At the point of maximum rise of the flying body, the following condition is met:

$$v_y=0. \tag{17}$$

Substituting into (17) the expression for v_y from (14), we find the flight time t_m to this point:

$$t_m=\frac{1}{\beta}\ln(1+\beta\sin\alpha). \tag{18}$$

Substituting the value t_m into the equations of motion (18), we obtain the equations for the geometric maximum rise of the trajectory:

$$\begin{aligned} x&=\frac{1}{2}\cdot\frac{\sin 2\alpha}{1+\beta\sin\alpha},\\ y&=\frac{1}{\beta^2}(\beta\sin\alpha-\ln(1+\beta\sin\alpha)). \end{aligned} \tag{19}$$

Relations (19) in a parametric form define the curve of maximum heights. Figure 1 shows curves (18) at some values β.

For $\beta\to 0$ equation (19) yields the equations of the maximum height curve in the absence of medium resistance:

$$\begin{aligned} x&=\frac{1}{2}\sin 2\alpha,\\ y&=\frac{1}{2}\sin^2\alpha. \end{aligned}$$

These equations were given in the paper (Seidametova and Temnenko, 2020). These equations describe the semi-ellipse:

$$\left(\frac{x}{1/2}\right)^2+\left(\frac{y-1/4}{1/4}\right)^2=1.$$
$$(x\geq 0; y\geq 0).$$

5 THE ENVELOPE FOR A BALLISTIC TRAJECTORY FAMILY

The envelope of the family of ballistic trajectories (16) satisfies the equations of motion (15) and the condition for the vanishing of the Jacobian $\frac{D(x,y)}{D(t,\alpha)}$:

$$\frac{D(x,y)}{D(t,\alpha)}=\begin{vmatrix} \dot{x} & \dot{y}\\ \frac{\partial x}{\partial\alpha} & \frac{\partial y}{\partial\alpha}\end{vmatrix}=0 \tag{20}$$

Relation (20) can be given the form:

$$v_x\frac{\partial y}{\partial\alpha}-v_y\frac{\partial x}{\partial\alpha}=0. \tag{21}$$

Calculating the derivatives by (15) $\frac{\partial x}{\partial\alpha}$ and $\frac{\partial y}{\partial\alpha}$ and substituting this into (21), we obtain a relation connecting the departure angle α and the time t at which the trajectory touches the envelope:

$$e^{-\beta t}=\frac{\sin\alpha}{\beta+\sin\alpha}. \tag{22}$$

Substitute (22) into equation (15) generates the envelope equation in parametric form:

$$\begin{aligned} x&=\frac{\cos\alpha}{\beta+\sin\alpha},\\ y&=\frac{1}{\beta^2}\left(\frac{\beta(1+\beta\sin\alpha)}{\beta+\sin\alpha}+\ln\left(\frac{\sin\alpha}{\beta+\sin\alpha}\right)\right). \end{aligned} \tag{23}$$

Since we considered only trajectories with $y\geq 0$, equations (23) describe the section of the envelope with $y\geq 0$ for values α of the parameter satisfying the inequalities:

$$\alpha_m\leq\alpha\leq\frac{\pi}{2}. \tag{24}$$

where α_m is the departure angle corresponding to the trajectory of the maximum flight range. Figure 2 shows the envelope of ballistic trajectories at some values of β.

6 FLIGHT DISTANCE AND THE FOLIUM OF GALILEO

The flight range l is the value of the horizontal coordinate x when the vertical coordinate y vanishes. Denote t_f the flight time of the object before falling. We also introduce the notation:

$$\tau=\beta t_f. \tag{25}$$

Assuming in (15) $y=0$ we establish a relationship between the departure angle α and the total flight time t_f:

$$\sin\alpha=\frac{1}{\beta}\frac{\tau-(1-e^{-\tau})}{1-e^{-\tau}}. \tag{26}$$

Assuming in (15) $t=t_f$ and substituting t_f into the expression for the coordinate x, we find the flight range l:

$$l=\frac{1}{\beta}\sqrt{1-\left(\frac{1}{\beta}\cdot\frac{\tau-(1-e^{-\tau})}{1-e^{-\tau}}\right)^2}\cdot\left(1-e^{-\tau}\right). \tag{27}$$

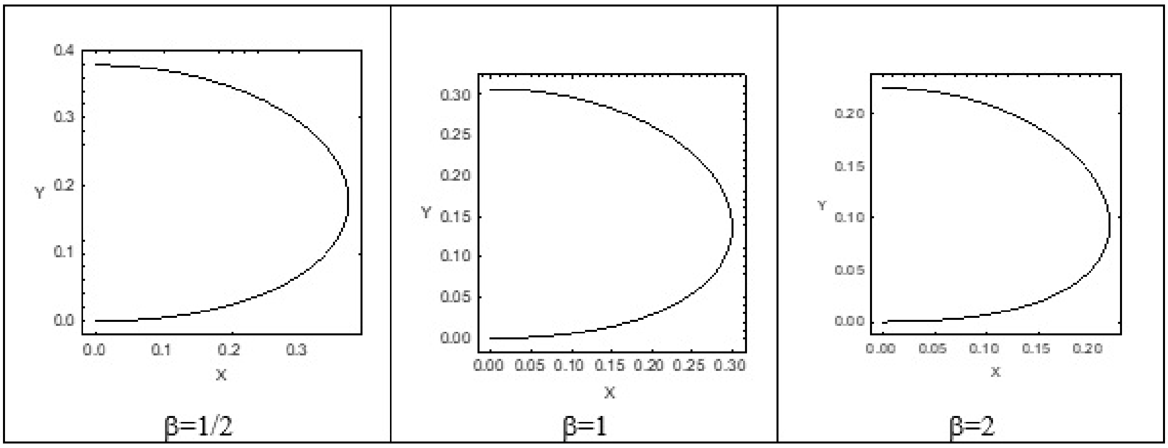

Figure 1: Curve of maximum heights of ballistic trajectories at a given β.

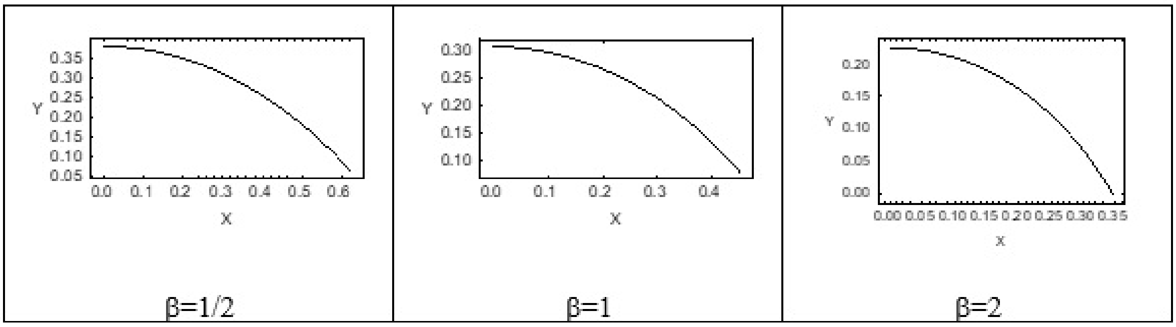

Figure 2: The envelope of the family of ballistic trajectories for some β.

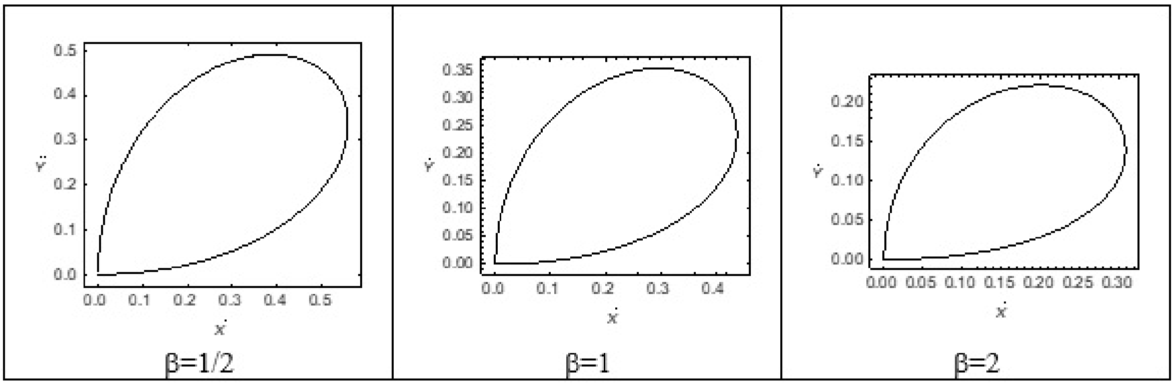

Figure 3: The folium of Galileo at some values of the dimensionless parameter of viscous resistance β.

Equations (27) together with the relation arising from (26):

$$\alpha = \arcsin\left(\frac{1}{\beta}\cdot\frac{\tau-(1-e^{-\tau})}{1-e^{-\tau}}\right), \tag{28}$$

define in a parametric form the dependence of the flight range l on the departure angle α. The parameter of this curve is the value τ.

Figure 3 shows the dependence $l = l(\alpha)$ at some β. As suggested in (Seidametova and Temnenko, 2020), this dependence is constructed in the form of a polar diagram, which we called "The folium of Galileo". The flight range l is interpreted as a radial coordinate in polar coordinates, and the angle α is interpreted as an azimuthal angle in polar coordinates.

When constructing figure 3, it should be noted that

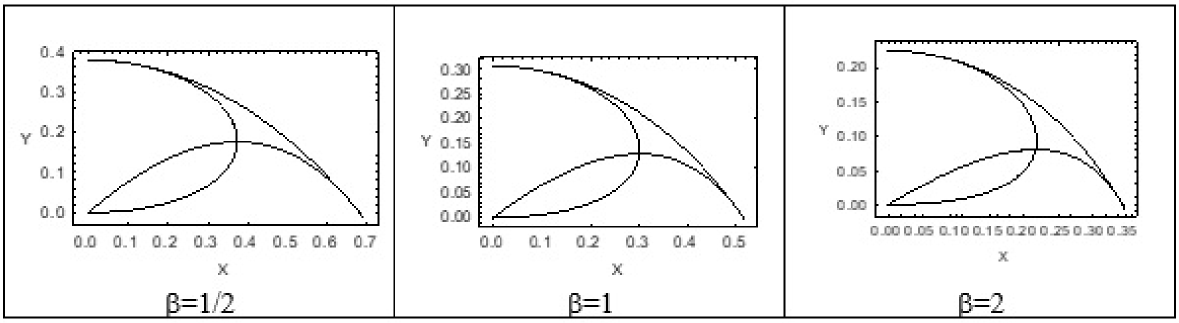

Figure 4: Galileo's Poleaxe for a ballistic problem with viscous resistance at some values of the resistance parameter β.

the parameter τ is bounded from above:

$$\tau \le \tau_*, \tag{29}$$

where τ_* is the solution to the equation:

$$F(\tau) = \frac{\tau}{1 - e^{-\tau}} = 1 + \beta. \tag{30}$$

determined by (30) for a given β, we build the folium of Galileo (27), (28) on the interval of change τ:

$$0 \le \tau \le \tau_*. \tag{31}$$

In the figure 3 $\tilde{x}$ and $\tilde{y}$ some conditional cartesian coordinates

$$\tilde{x} = l(\alpha) \cdot \cos\alpha,$$
$$\tilde{y} = l(\alpha) \cdot \sin\alpha.$$

7 GALILEO'S POLEAXE

Knowing the envelope of the family of ballistic curves (23) and the curve of maximum altitudes (19), as well as adding to these curves the trajectory of the farthest flight, we can build a composite curve – Galileo's Poleaxe (figure 4).

When constructing the trajectory of the farthest flight, it is necessary using curve from figure 3, to set the angle α_{max} corresponding to the farthest flight and substitute this value of the angle α into equation (15).

8 GALILEO'S DOME

If in the equation of a one-parameter family of the ballistic trajectories (16) we reinterpret the triple (x, y, α) as a triplet of cylindrical coordinates (ρ, z, φ): $x \equiv \rho$; $y \equiv z$; $\alpha \equiv \varphi$, then the equation of the *family of curves* (16) turns into the equation of *one surface* given explicitly in cylindrical coordinates $z = z(\rho, \varphi)$:

$$z = \frac{1}{\beta^2}\left((1 + \beta\sin\varphi)\frac{\beta\rho}{\cos\varphi} + \ln\left(1 - \frac{\beta\rho}{\cos\varphi}\right)\right). \tag{32}$$

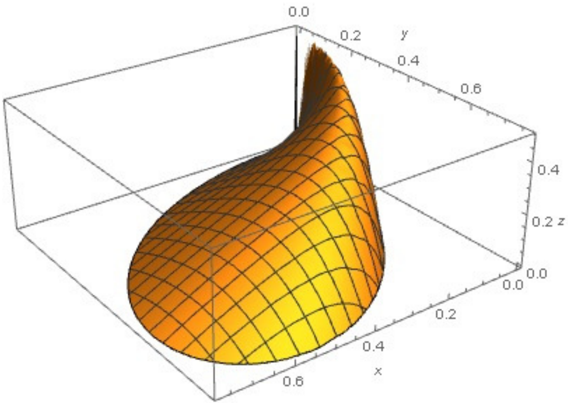

Figure 5: The Galileo's dome for $\beta = 0$.

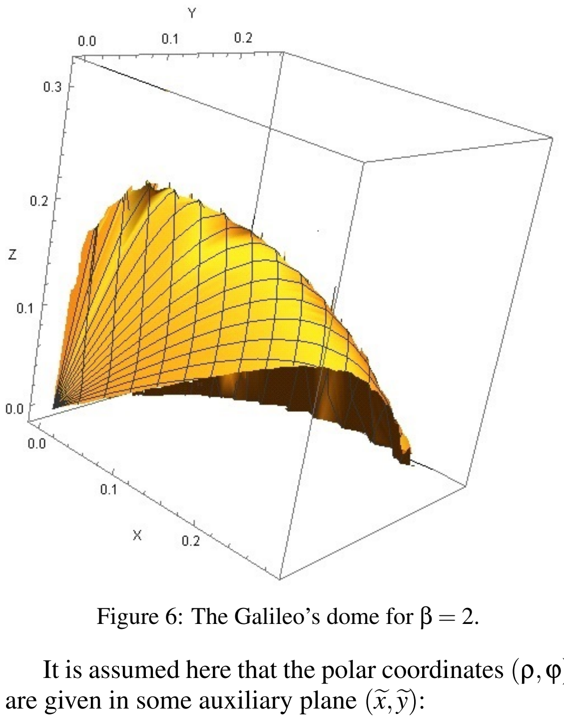

Figure 6: The Galileo's dome for $\beta = 2$.

It is assumed here that the polar coordinates (ρ, φ) are given in some auxiliary plane $(\widetilde{x}, \widetilde{y})$:

$$\widetilde{x} = \rho\cos\varphi;\ \widetilde{y} = \rho\sin\varphi.$$

Equation (32) describes (for $z \ge 0$ and

$0 \leq \varphi \leq \frac{\pi}{2}$) a certain surface (figure 5), which we call “Galileo’s dome”. Galileo’s dome provides a visual representation of the entire set of ballistic trajectories as some whole geometric object (figure 6).

9 CONCLUSIONS

The paper presents a solution to the problem of a family of ballistic trajectories in a medium with linear viscous resistance. The equations of the envelope of the family of trajectories and the equation of the curve of the highest elevation of the trajectory are presented in a parametric form. The polar diagram of the flight range is presented in parametric form. The paper also presents a geometric interpretation of the entire set of ballistic trajectories in the form of the some surface – the Galileo’s dome.

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An Inverse Method of the Natural Setting for Integer, Half-integer and Rational "Perfect" Hypocycloids

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Keywords: Hypocycloid, Perfect Hypocycloid, Inverse Method of Natural Setting for Planar Curves.

Abstract: The paper describes a family of remarkable curves (integer and half-integer hypocycloids and rational perfect hypocycloids) given in an inverse-natural form using a simple trigonometric relation $s = s(\chi)$, where s is the arc coordinate and χ is the angle defining the direction of the tangent. In the paper we presented all perfect hypocycloids with the number of cusps $\nu \leq 10$. From designing the hypocycloid using inverse natural setting easy to determine the number of cusps and find the values of the λ_m parameter, corresponding to perfect hypocycloids.

1 INTRODUCTION

Many remarkable curves have emerged in mathematics over the past centuries. The study of these curves is a very effective tool in the teaching of calculus, differential geometry and computer science. Many great curves are described in the classical book "A Catalog of Special Plane Curves" (Lawrence, 2014) that featured more than 60 special curves. The other work on plane curves is "A handbook on curves and their properties" (Yates, 2012). This handbook contains curves constructions, equations, physical and mathematical properties, and connections to each other.

Wang et al. (Wang et al., 2019) explored hypocycloid's parametric equation and discussed the application of the astroid on the bus door for saving space. For simulating its dynamic opening process, they used MATLAB. There are a lot of examples of the using curves and surfaces innovation in the architectural designs of modern buildings (Biran, 2018).

Almost all curves can be represented mathematically and on a computer. The mathematical study of curves and surfaces in space is called "differential geometry". There are a lot of mathematical tools available to the computer scientist. The combination of these tools depends on what and how curves need to be represented.

There are different types of curves using in the design of geometric data structures. For example, Space-Filling Curves described in the papers (Asano et al., 1997; Rad and Karimipour, 2019).

There are a lot of ways to define curves. One of the most convenient ways to describe a plane curve is the "Euler" or "natural" way of locally defining the curve. In this method, the angle of inclination of the tangent is set as a function of the length of the arc along the curve.

In some situations, the "reverse" method of "natural" curve definition is convenient, in which the arc length is set as a function of the angle of inclination of the tangent. We will demonstrate in this article how convenient this "reverse" method is when describing some types of hypocycloids.

2 AN INVERSE METHOD OF THE NATURAL SETTING FOR PLANAR CURVES

One well known way to define flat curves is to describe them in the so-called natural form (or, another name is "Euler's form"):

$$\chi = \chi(s), \tag{1}$$

where χ is an angle between some fixed direction – for example, the x-axis – and the direction of the tangent to the curve; s is the arc coordinate along the curve.

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An Inverse Method of the Natural Setting for Integer, Half-integer and Rational "Perfect" Hypocycloids.
In *Proceedings of the 1st Symposium on Advances in Educational Technology (AET 2020) - Volume 2*, pages 584-589
ISBN: 978-989-758-558-6

If the natural equation of the curve (1) is known, then the equations of the corresponding curve in parametric form $x = x(s)$, $y = y(s)$ can be written in the following form:

$$x = \int_0^s \cos\chi(s)\mathrm{d}s + x_0,$$
$$y = \int_0^s \sin\chi(s)\mathrm{d}s + y_0, \tag{2}$$

where (x_0, y_0) is an arbitrarily chosen point (x, y) in the plane, corresponding on the curve to the origin of the arc coordinate $s = 0$.

Leonhard Euler studied a family of curves of the form (1) with a power-law dependence of χ on s ($\chi = \lambda s^p$, $\lambda = const$, $p = const$) (MacTutor History of Mathematics, 2020). Euler called these curves as "clothoids". The most famous of these curves for p=2 is called the "Euler spiral" or "Cornu spiral". Euler investigated this curve a century earlier than did Marie Alfred Cornu.

Instead of the equation (1), we can consider the *inverse* method of natural setting for the curve:

$$s = s(\chi). \tag{3}$$

This method is convenient if the function inverse to (3) is multivalued or does not have an explicit analytic expression.

Equations (2) with this method for specifying the curve (3) become:

$$x(\chi) = \int_0^\chi \cos\chi \cdot \frac{\mathrm{d}s}{\mathrm{d}\chi}\mathrm{d}\chi + x_0,$$
$$y(\chi) = \int_0^\chi \sin\chi \cdot \frac{\mathrm{d}s}{\mathrm{d}\chi}\mathrm{d}\chi + y_0. \tag{4}$$

Equations (4) define a parametric description of the curve. In this specification parameter χ has clear geometric meaning: it is the angle between the axis x and the direction tangent to the curve.

3 INTEGER HYPOCYCLOIDS

We consider in this note a one-parameter family of curves of the form (3):

$$s = \frac{n^2-1}{n^2} \cdot \sin(n\chi), \tag{5}$$

in which $n \geq 2$ is an integer parameter. Let's call the equation (5) the "trigonometric Euler relation". This relation in local variables (s, λ) describes the classic family of curves: integer hypocycloids.

For an even value of n, the range of the function (5) is $0 \leq \chi \leq 2\pi$. For an odd value of n, the range of the function (5) is $0 \leq \chi \leq \pi$. On this interval the trigonometric Euler's relation (5) defines a closed curve.

Assuming that $x_0 = 0$, $y_0 = 1/n$, and performing the integration in (4), we obtain the equations of the integer hypocycloids in parametric form:

$$x = \frac{1}{2n}\Big((n+1)\sin\big((n-1)\chi\big) + (n-1)\sin\big((n+1)\chi\big)\Big),$$
$$y = \frac{1}{2n}\Big((n+1)\cos\big((n-1)\chi\big) - (n-1)\cos\big((n+1)\chi\big)\Big). \tag{6}$$

4 CUSPS OF THE INTEGER HYPOCYCLOIDS

The curves (6) are smooth everywhere except the points $\chi_{n,k}$, in which the cusps of the curve (6) are located. The positions of the cusps' vertices are determined by the points of a curvature singularity of the curve (6):

$$\chi'_s = \frac{1}{s'_\chi} = \frac{n}{(n^2-1)\cos(n\chi)}. \tag{7}$$

Respectively, the cusp-points are zeros of $\cos(n\chi)$:

$$\chi_{n,k} = \frac{\pi}{2n}(2k+1). \tag{8}$$

Let ν denote a number of cusps for the integer hypocycloids (6). In equation (8) k can take $2n$ values for even n $(0 \leq k \leq 2n-1)$ and n values for odd $(0 \leq k \leq n-1)$. Accordingly, the integer hypocycloids can have an odd number of ν cusps at $n = 2m+1$ or the it can have ν as a multiple of 4 ($\nu = 4m$ at $n = 2m$). There is no integer hypocycloids with $\nu = 4m+2$ cusps – for example, there is no six-pointed "Euler star", but there is a five-pointed Euler star, eight-pointed and twelve-pointed Euler stars.

Substituting (8) into (6), we define the positions of the cusps' vertices on the plane (x, y):

$$x_{n,k} = (-1)^k \cos\left(\frac{\pi}{2n}(2k+1)\right),$$
$$y_{n,k} = (-1)^k \sin\left(\frac{\pi}{2n}(2k+1)\right). \tag{9}$$

All the cusps' vertices (9) lie on a circle of unit radius with the center at the origin.

5 APPEARANCE OF THE INTEGER HYPOCYCLOIDS

Figures 1-5 show an appearance of the integer hypocycloids with the number of rays ν, equal to 3, 4, 5, 8 and 12.

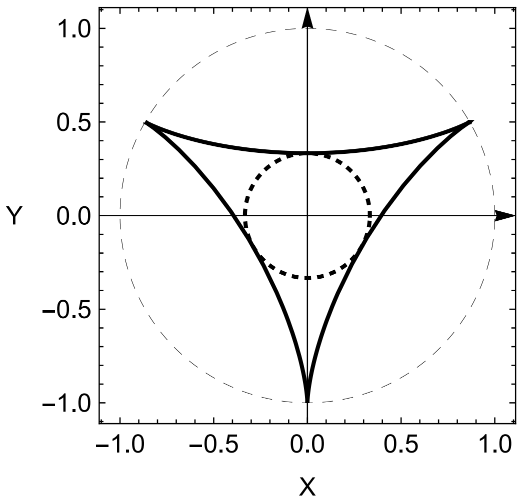

Figure 1: The tricuspidate hypocycloid (deltoid) ($n = 3$, $\nu = 3$).

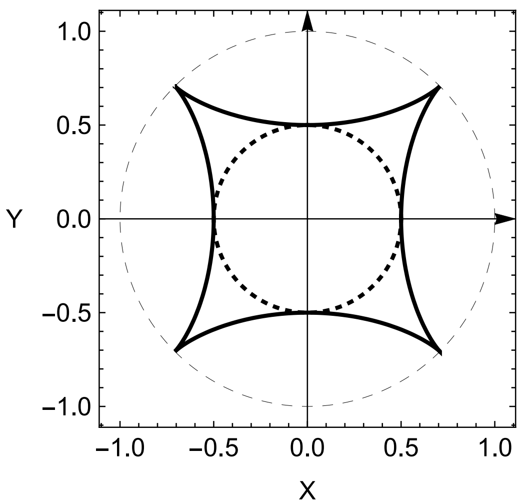

Figure 2: The tetracuspidate hypocycloid (astroid) ($n = 2$, $\nu = 4$).

6 HALF-INTEGER HYPOCYCLOIDS

Consider the half-integer hypocycloid, assuming that in equations (5) and (6) the integer parameter n is replaced by a half-integer $n \to n + \frac{1}{2}$ ($n \geq 1$).

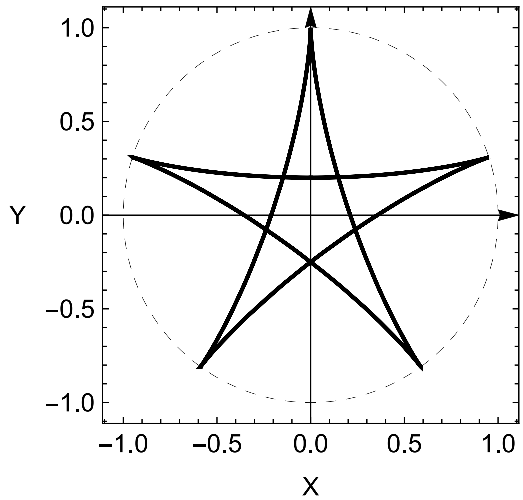

Figure 3: The pentacuspidate hypocycloid (the integer hypocycloid with $n = 5$, $\nu = 5$).

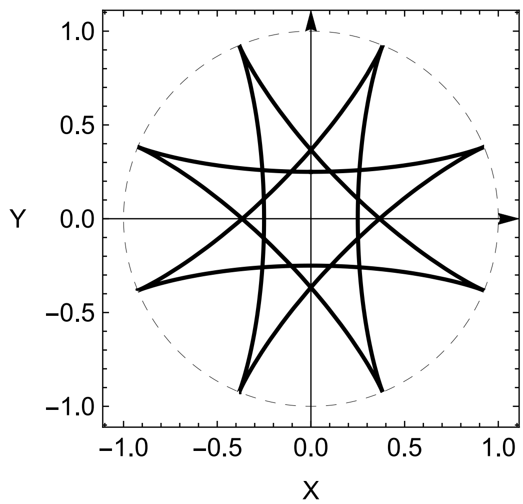

Figure 4: The octacuspidate hypocycloid (the integer hypocycloid with $n = 4$, $\nu = 8$).

With half-integer parameter, the hypocycloid equations (5) and (6) take the following form:

$$s = \frac{(2n-1)\,(2n+3)}{(2n+1)^2}\,\sin\Big(\,(2n+1)\,\frac{\chi}{2}\Big), \qquad (10)$$

$$\begin{aligned} x &= \frac{1}{2\,(2n+1)}\Big(\,(2n+3)\sin\Big(\,(2n-1)\,\frac{\chi}{2}\Big) + \\ &\qquad + (2n-1)\sin\Big(\,(2n+3)\,\frac{\chi}{2}\Big)\Big), \\ y &= \frac{1}{2\,(2n+1)}\Big(\,(2n+3)\cos\Big(\,(2n-1)\,\frac{\chi}{2}\Big) - \\ &\qquad - (2n-1)\cos\Big(\,(2n+3)\,\frac{\chi}{2}\Big)\Big). \end{aligned} \qquad (11)$$

The functions $x(\chi)$ and $y(\chi)$ (11) are periodic in the argument χ with a period $\mathcal{P} = 4\pi$.

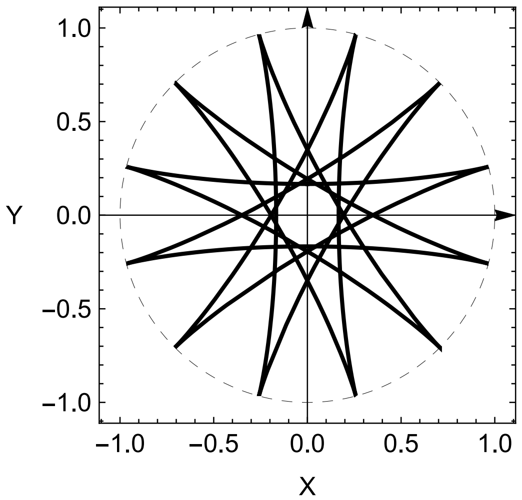

Figure 5: The dodecacuspidate hypocycloid (the integer hypocycloid with $n = 6$, $\nu = 12$).

The positions of the cusps of the half-integer hypocycloid (11) are determined by the condition:

$$\frac{ds}{d\chi} = 0, \tag{12}$$

or

$$\chi_k = \pi\frac{2k+1}{2n+1}; \quad 0 \le k \le k_{max} = 4n+1. \tag{13}$$

The number of cusps ν is determined by the condition

$$\nu = 1 + k_{max} = 4n+2. \tag{14}$$

In accordance with (14), half-integer hypocycloids together with integer hypocycloids make it possible to obtain an hypocycloid with any number of rays. In particular, for $n = 1$, equation (1) describes a six-beam astroid.

Figure 6 and figure 7 show half-integer hypocycloids at $n = 1$ (figure 6) and $n = 2$ (figure 7).

A half-integer hypocycloid with $n = 1$ has no self-intersection points (like two integer hypocycloids of the lowest index 1, even and odd). The remaining half-integer hypocycloids with $n \ge 2$ (and integer hypocycloids with index $n \ge 2$) have self-intersection points. The half-integer hypocycloids are located in the ring between $R_{min} = \dfrac{2}{2n+1}$ and $R_{max} = 1$. It is easy to show that these curves touch a circle of radius R_{min} in $\nu = 4n+2$ points for $\chi_{t,k}$:

$$\chi_{t,k} = \frac{2\pi k}{2n+1}; \quad 0 \le k \le k_{max} = 4n+1. \tag{15}$$

The totality of integer and half-integer hypocycloids forms the set of figures, called in (Seidametova and Temnenko, 2019) “The Euler Insignia”.

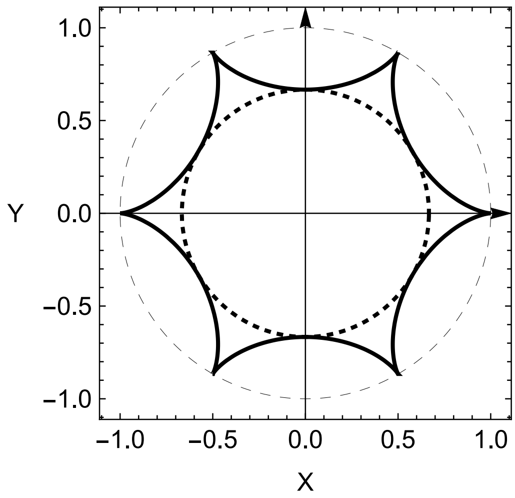

Figure 6: The half-integer hypocycloid at $n = 1$(the six-pointed star).

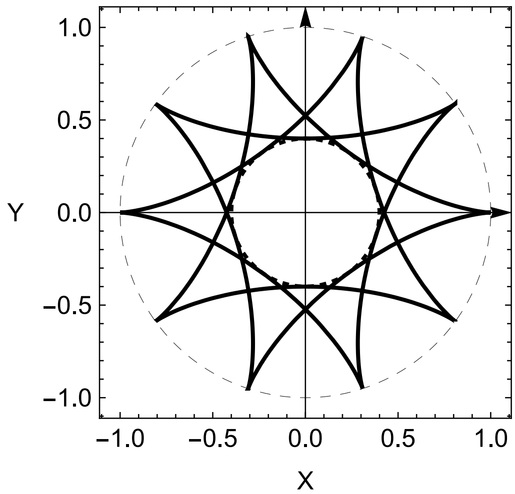

Figure 7: The half-integer hypocycloid at $n = 2$ (the ten-pointed star).

7 THE PERFECT HYPOCYCLOIDS

Let’s call a hypocycloid “perfect” if it has no self-intersection points. An example of a perfect hypocycloid is the deltoid (an odd integer hypocycloid with $n = 3$ and $\nu = 3$, figure 1), the astroid (an even integer hypocycloid, $n = 2$, $\nu = 4$, figure 2) and the six-point star (the half-integer hypocycloid, $n = 1$, $\nu = 6$, figure 6). All other integer and half-integer hypocycloids, in particular, shown in figures 3, 4, 5, 7, are not perfect.

Perfect hypocycloids are described by the trigonometric Euler relation (5), in which an integer n is replaced by some rational number λ_m of a certain type. The parameter λ_m is an irreducible fraction of one of three possible types:

$$\lambda_m = \frac{2m+1}{2m-1}; \quad m \geq 1. \tag{16}$$

$$\lambda_m = \frac{2m}{2m-1}; \quad m \geq 1. \tag{17}$$

$$\lambda_m = \frac{2m+1}{2m}; \quad m \geq 1. \tag{18}$$

Let call perfect hypocycloids of the type (16) the Odd-Odd perfect hypocycloids. Let call perfect hypocycloids of the type (17) the Even-Odd perfect hypocycloids. Let call perfect hypocycloids of the type (18) the Odd- Even perfect hypocycloids. For $m = 1$ a perfect hypocycloid of the type (16) is an integer hypocycloid with three cusps (the deltoid, figure 1), a perfect hypocycloid of the type (17) is an integer hypocycloid with four cusps (the astroid, figure 2), a perfect hypocycloid of the type (18) is a half-integral six-pointed star (figure 6).

Figure 8 shows the Odd-Odd perfect hypocycloid with $m = 2$ (the "five-pointed star of Euler"). In accordance with relations (5) and (6) and the value $\lambda_m = 5/3$, the equations of this perfect hypocycloid have the form:

$$s = \left(\frac{4}{5}\right)^2 \sin\left(\frac{5\chi}{3}\right), \tag{19}$$

$$\begin{aligned} x &= \frac{1}{5}\left(4\sin\left(\frac{2\chi}{3}\right) + \sin\left(\frac{8\chi}{3}\right)\right), \\ y &= \frac{1}{5}\left(4\cos\left(\frac{2\chi}{3}\right) - \cos\left(\frac{8\chi}{3}\right)\right). \end{aligned} \tag{20}$$

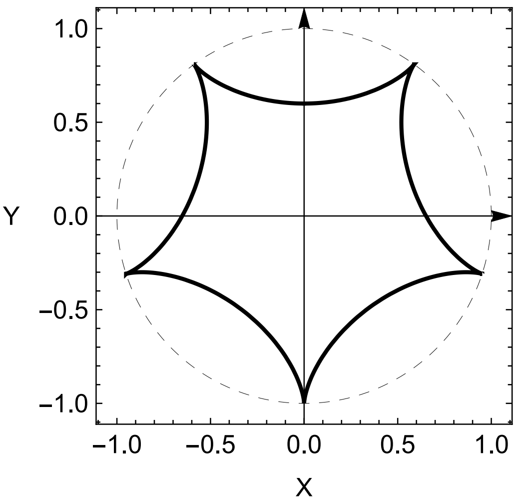

Figure 8: The Odd-Odd perfect hypocycloid with $m = 2$ ($\lambda_m = 5/3$, the five-pointed star of Euler).

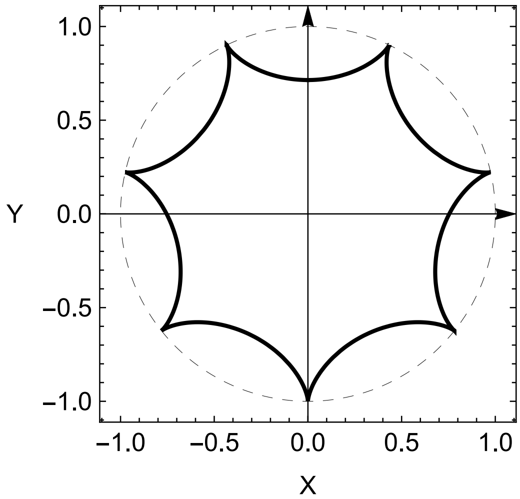

Figure 9: The Odd-Odd perfect hypocycloid with $m = 3$ ($\lambda_m = 7/5$, the seven-pointed star of Euler).

Figure 9 shows the Odd-Odd perfect hypocycloid with $m = 3$ ($\lambda_m = 7/5$, the "seven-pointed star of Euler"). The equations of this hypocycloid are following:

$$s = \frac{24}{49} \sin\left(\frac{7\chi}{5}\right), \tag{21}$$

$$\begin{aligned} x &= \frac{1}{7}\left(6\sin\left(\frac{2\chi}{5}\right) + \sin\left(\frac{12\chi}{5}\right)\right), \\ y &= \frac{1}{7}\left(6\cos\left(\frac{2\chi}{5}\right) - \cos\left(\frac{12\chi}{5}\right)\right). \end{aligned} \tag{22}$$

Figure 10 shows the Odd-Odd perfect hypocycloid with $m = 4$ ($\lambda_m = 9/7$). This is the "nine-pointed Euler star"). The equations of this curve are following:

$$s = \frac{32}{81} \sin\left(\frac{9\chi}{7}\right), \tag{23}$$

$$\begin{aligned} x &= \frac{1}{9}\left(8\sin\left(\frac{2\chi}{7}\right) + \sin\left(\frac{16\chi}{7}\right)\right), \\ y &= \frac{1}{9}\left(8\cos\left(\frac{2\chi}{7}\right) - \cos\left(\frac{16\chi}{7}\right)\right). \end{aligned} \tag{24}$$

Figure 11 shows the Even-Odd perfect hypocycloid with $m = 2$ ($\lambda_m = 4/3$). This is the "eight-pointed Euler star"). The equations of this curve are following:

$$s = \frac{7}{16} \sin\left(\frac{4\chi}{3}\right), \tag{25}$$

$$\begin{aligned} x &= \frac{1}{8}\left(7\sin\left(\frac{\chi}{3}\right) + \sin\left(\frac{7\chi}{3}\right)\right), \\ y &= \frac{1}{8}\left(7\cos\left(\frac{\chi}{3}\right) - \cos\left(\frac{7\chi}{3}\right)\right). \end{aligned} \tag{26}$$

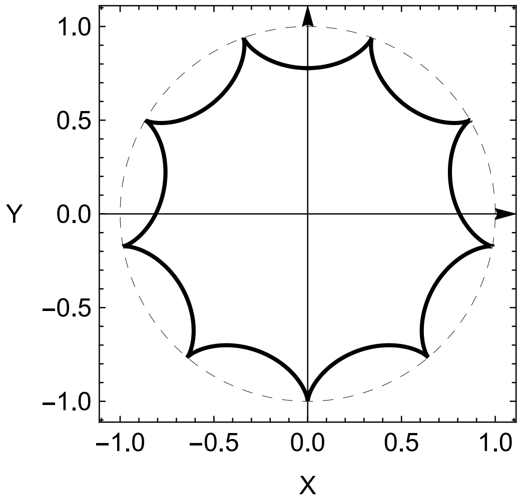

Figure 10: The Odd-Odd perfect hypocycloid with $m = 4$ ($\lambda_m = 9/7$, the nine-pointed Euler star).

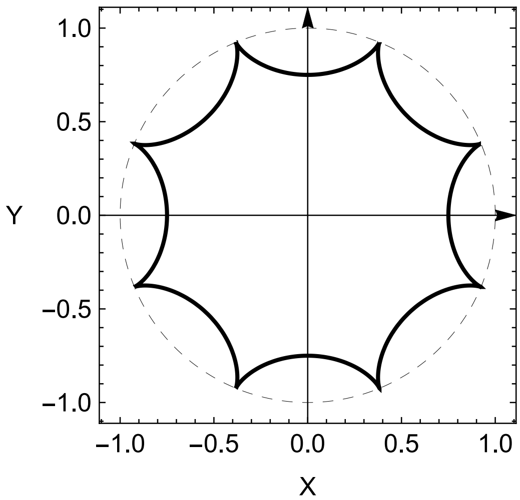

Figure 11: The Even-Odd perfect hypocycloid with $m = 2$ ($\lambda_m = 4/3$, the eight-pointed Euler star).

Figure 12 shows the Odd-Even perfect hypocycloid with $m = 2$ ($\lambda_m = 5/4$). This is the "ten-pointed Euler star"). The equations of this curve are following:

$$s = \left(\frac{3}{5}\right)^2 \sin\left(\frac{5\chi}{4}\right), \tag{27}$$

$$\begin{aligned} x &= \frac{1}{10}\left(9\sin\left(\frac{\chi}{4}\right) + \sin\left(\frac{9\chi}{4}\right)\right), \\ y &= \frac{1}{10}\left(9\cos\left(\frac{\chi}{4}\right) - \cos\left(\frac{9\chi}{4}\right)\right). \end{aligned} \tag{28}$$

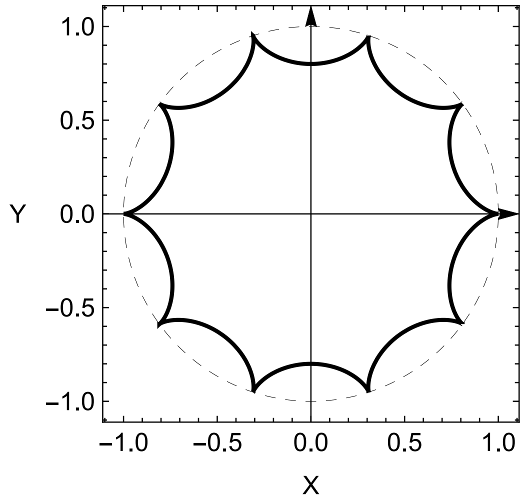

Figure 12: The Odd-Even perfect hypocycloid with $m = 2$ ($\lambda_m = 5/4$, the ten-pointed Euler star).

8 CONCLUSIONS

Figures 1, 2, 6, 8, 9, 10, 11, 12 presented in the paper demonstrate all perfect hypocycloids with the number of cusps $\nu \leq 10$.

Designing the hypocycloid by inverse natural setting makes it easy to determine the number of cusps and find the values of the λ_m parameter ((16), (17) and (18)), corresponding to perfect hypocycloids.

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